Towards a Process of Making

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Erasmus Intensive Programs “Tectonics in Building Culture” & “Structures in Building Culture” 2007–2014

> *By rejecting the wisdom and resistance of tradition, architecture also drifts towards a deadening uniformity on the one hand, and towards a rootless anarchy of expression on the other. Every art form has its ontology as well as its characteristic field of expression, and limits are posed by its very essence, inner structures and materials. Generating architectural expression from the unquestionable realities of construction is the long tradition of the art of architecture. The tectonic language of architecture, the inner logic of construction itself, expresses gravity and structure, the language of materials as well as processes of construction and details of joining units and materials to one another.*[1]

One to one with a view: Erasmus IP 2014, Tuass, Liechtenstein

Revealing Material and Local Building Traditions

How do we build today, and what are the principles underlying the architectonic expression of our buildings? As a result of increasing demands for comfort, the general mechanization of the construction process and the consequent detaching of constructive logic from materials in recent years, many local building traditions are becoming a thing of the past. The diversity of building traditions developed within Europe's regional cultures, and nurtured for centuries, has been displaced by arbitrarily exchangeable constructions and building materials. Consequently, regional building cultures and associated craft traditions are no longer taken into consideration and are becoming increasingly lost. The definition of regional building cultures that Friedrich Achleitner so accurately describes in 'Region, ein Konstrukt? Regionalismus, eine Pleite?' is one not to be ignored in this context. Achleitner understands regional building, embedded within the circumstances and resources of a region, as the immediate expression of a self-contained living environment as evolving from a network of relationships between landscape, climate, economic model and existing materials, as well as political and natural borders.[2] Today, with regions opening themselves up irreversibly, an internationalization of construction has occurred, negating the local and elevating the general.

Concurrent with this loss of regional building cultures and craft knowledge of local building materials, architectural training has likewise detached itself from the

1 PALLASMAA, Juhani, The Working Hand, Chichester, West Sussex (John Wiley & Sons Ltd) 2009, p. 113

2 ACHLEITNER, Friedrich, Region, ein Konstrukt? Regionalismus, eine Pleite?, Basel (Birkhäuser) 1997, pp. 165–166

Cross country cabin: Loipahötta in Steg, Liechtenstein

logic of joining existing building materials. The tempting potential of the digital world increasingly encourages the development of a globalized architecture. The constructive interplay of the regional and cultural with materials has, similarly to built architecture, also received little consideration in architectural training, with student designs increasingly resulting in an international mishmash of architecture, which then becomes applicable to each and every situation in a non-specific manner. However, the consequences of a dominant global mainstream of architectural production are easily observable in the cultural monotony of today's agglomerations.

In order to counteract these two tendencies, a consortium of European architectural schools, coordinated by the University of Liechtenstein, has developed the idea of an Erasmus Intensive Programme (IP), addressing building cultures and the materials that have traditionally been anchored regionally, exploring these experimentally and above all structurally in workshops. Due to the successful results and an increasing interest in these issues, the partnership expanded over the course of the IP series 'Tectonics in Building Culture' and 'Structures in Building Culture', between 2007 and 2014, to nine European partner universities.

The assembly of a primary hut: Jean Goujon, Architektur oder die Kunst des Guten Bauens, Jean Martin, Paris, 1553

Cultivating the Process of Making at Full Scale

The process of making at scale 1:1 was, from the beginning, located at the centre of the series of workshops, which were tailored to the specific characteristics of the particular building materials used. To become familiar with the material and to get to know and test its properties, each workshop started off with quick and lively experiments at scale 1:1. The second part of the workshop, depending on the possibilities provided by the locale, involved the production of permanent or temporary objects designed and developed from these experiments. Today, as a result of various Erasmus Intensive Programmes, objects built from wood are still standing in Norway and Liechtenstein, ones from wicker in Poland, concrete in Denmark, and stone in Ireland.

The workshops have always been accompanied by craftspeople who have passed on their traditional knowledge to both students and tutors. The significance of the hand and its interplay with materials and tools, for both the architect and in crafts, has been very impressively described in the essay *The Working Hand* by Juhani

Pallasmaa[3]. Direct contact with such building materials as concrete, stone, brick, wicker and wood during workshops has always played a crucial role. The touch of the hand and smell, and an exploration of physical qualities, were important aspects. The material as the impetus for architectural design has always played a central role. The laboratory situation of the various universities was deliberately abandoned, in order to test the built experiments within the real environment and at full scale. The experiences and results obtained during the series of workshops enhanced the knowledge of students and tutors alike, simultaneously contributing to the distribution of knowledge about various regional building cultures in different European countries. An attendant awareness within European building culture is an important aspect which may contribute to an identification with the diversity of European culture.

Structure and cover: “tateana” the Japanese archetypical hut

Transforming Experience and the Art of Play
Mixed teams from all the partner universities created the possibility of transforming the knowledge that resulted from making. Consequently, Dutch brick-building culture could be linked to Danish knowledge and traditions, and the approaches to wood specific to Norway and Liechtenstein could be fervently discussed. This led on the one hand to the maintaining of individual regional traditions, and on the other enabled completely new perspectives. The Erasmus Intensive Programmes demonstrated that this not only inspired an awareness of European building cultures but was also fruitful to discussions around this subject within the European universities, both of which are of great importance. The texts that have been contributed to this publication consider the two IP series ‘Tectonics in Building Culture’ and ‘Structures in Building Culture’, which took place between 2007 and 2014. They summarize the insights gained, weaving them together whilst also identifying differing points of view. They facilitate the further distribution of our findings, and at the same time provide an involvement with the extraordinary wealth of European building culture that has evolved with a place in today’s architectural training.

Carmen Rist, Urs Meister,
University of Liechtenstein

3 PALLASMAA, Juhani, The Working Hand, Chichester, West Sussex (John Wiley & Sons Ltd) 2009, pp. 47–69

Didactic concepts for teaching architecture at scale 1:1 – Two Case Studies

Building practice at scale 1:1 has existed as an educational tool within the Faculty of Architecture and Fine Art at the NTNU University for more than fifteen years. This includes ten years of participation in the Erasmus IP workshop 'Tectonics in Building Culture'. This way of studying to become an architect is growing fast and today it takes place both in Norway and around the world.

Among educational tools we can discern different directions. One involves cases where a location and regional materials generate a 1:1 structure with a minimum of advance planning. Another is construction work based on previously designed and planned projects. Between these two practices, variations of educational tools have been developed. This study is based on experienced knowledge that leans on the theories of Plato (428–348 BC) and Aristotle (384–322 BC). This compares the two cases built in Norway: *Case study I* a Protection Shed built during the Erasmus IP workshop at Hopsjø in 2007; and *Case study II* a Sauna at Vang in Valdres built during a master's course at the Faculty of Architecture and Fine Art at the NTNU in 2015.

Covering the period between 2007 and 2015, the study investigates the meaning of tectonics in relation to craftsmanship versus an experimental approach, and to industrial production versus the notion of local materials, and to the question of sustainable development in a region in times of globalization.

Introduction

One important aspect of tectonic thinking is to have a nearness to and a deep knowledge of materials. This enables one to search for the roots of architecture. As an educational tool, building at scale 1:1 develops basic tectonic ideas. The poem by the American poet Ezra Pound (1885–1972) expresses the vision of where we can find a source to renew the architecture.

> *Music degenerates if it moves too far away from dance, and poetry shrivels if it becomes too remote from music and song. In the same way, architecture has its own origin, and if it moves too far away from it, it loses its effectiveness. The renewal of an art means rediscovering its deepest essence.*

Teaching in presence versus representation

In architectural education today, project work in a studio is a traditional and well-established method of teaching. A project includes one or more tasks in which students make proposals for a building, for example a family home, school or factory through drawings, models, photos and text. This way of learning often mimics practice outside the studio. A typical aspect of project work is when the supervisor does not teach formal meanings and values, but rather creates an environment for teaching which relates to real life outside the studio. The teacher often aims to meet each student where he or she is, trying to clarify steps to take. In this process the intention is to encourage the student to find their own questions and answers.

Practice in today's architecture office has a character which is mainly representative[1]. In other words, it is based on developing representations of architecture. These representations are the most recognized way to contain and communicate a project until one day it gets built. When a person finally enters the built house, they can experience the room, the scale, the light, the materials, the use and the atmosphere. Only then is the architecture no longer representative, but present.

With architectural education at scale 1:1, this changes one's understanding on several levels. The creative process changes from computer and pencil to hammer and saw. The questions, challenges and solutions become different. The dialogue between the architect and the craftsman is not only a meeting between two areas of knowledge but also a meeting man to man. This is possibly what the American philosopher John Dewey (1859–1952) means when he says that knowledge and philosophy have a fluent character which will always change, while craftsmanship has another character, where the moment of action demands a yes or no, or a right and wrong.

Learning from Greek philosophy

Behind the effort to teach architecture at scale 1:1, there are ongoing pedagogical and esthetical discussions. How can we establish an understanding that includes experiences and knowledge of such different characters? In the process of architectural creation, the notion of the tectonic should not be isolated. Instead, it should interplay with values like integrating and developing science and at the same time ask

1 Text by Alberto Pères-Gòmez entitled 'Architecture and Crises of Modern Science', MIT Press 1983. Gòmez discusses what he understands as a problematic division between the representative studio work of the architect and what is happening on the building site in the hands of the worker. He describes how the documents handed over by the architect on site do not constitute a vision of architecture. He considers this separation between the two professions as a threat and offers suggestions about how to bridge the gap.

ethical questions about what purpose architecture serves. Might we possibly learn from the ancient Greek philosophers about the ideas of episteme, techne and phronesis?

1 Episteme contains the theoretical, abstract and provable, which is normally understood as the true notion of scientific knowledge.

2 Techne is what Aristoteles understands as questions related to production, and also to the production of products. Skills are a production capacity. This understanding also includes practical skills and professional knowledge, in addition to instrumental knowledge and artistic work. The act of production Aristoteles describes as poises. The notion of Poises here means 'to make something which did not exist before'.

3 Phronesis is the ethical and political value, where humans always belong to a society. This means that to act in accordance with phronesis demands an ability to deviate from general rules of acting, in relation to what is needed, in a concrete situation. Phronesis represents the ability to decide what is good, meaningful and useful for mankind.

Consciously or unconsciously, these three ideas have been a common aspect of the Erasmus IP programme at Hopsjø and of the BADSTU sauna in Vang, but in different ways. When teaching architecture at scale 1:1 at a certain location, it is important to apply these ideas so that they inform and develop one another.

Case study I – A protection shed at Hopsjø

Hopsjø is a small settlement on Hitra Island in the North Sea, off the coast to the west of Trondheim. For centuries the conditions for life here were based on trade, farming and fishing.

Hopsjø was founded at the beginning of the 18th century with the export of dry fish to southern Europe. The returning boats brought back useful implements, jewellery, handicraft and wine. In the early 20th century, the canning industry based on fish and whale meat provided a new economic foundation for the settlement. Today Hopsjø has lost is former conditions of life. There is a growing local effort to restore traditional houses for accommodation and small fishing boats for rent. The yearly summer Hopsjø Festival is also part of this renewal. Within this local vision to transform Hopsjø, the Erasmus IP workshop was invited to make a cultural intervention to support the initiative. On 8 July 2007, a bus with 26 architecture students from

Liechtenstein, Portugal, Spain, Slovenia, Denmark, Egypt and Norway arrived at Hopsjø. During the days, three travelling carpenters from Austria, 'Zimmerleute auf der Walz', stopped by and worked for four days. After eight intensive days the Protection Shed for the Hopsjø Summer Festival, and for protecting the wooden sailing boats in winter, was completed and handed over to the community.

Materials
The framework of materials for the construction was local spruce, all in lengths of 300 cm and within only three dimensions:

- 3 × 3 inches for the main structure 200 pieces
- 3 × 1½ inches for econdary elements 200 pieces
- 3 × 1 inches wall cladding 280 pieces
- Handmade local shingles of larch 18000 pieces
- Joints: Wooden dowels for the skeleton construction and iron nails for the cladding.

Tools
Handsaw, chisel, plane and hammer.

Concept
In coastal areas with limited access to forests and wooden materials, the building tradition has developed structural systems that make economic use of wood. A skeleton structure with wooden cladding is a traditional 'grind' system. This is an optimized structure with minimal use of materials. The Protection Shed at Hopsjø follows this tradition by its repetition of wooden frames as the structure, connections with wooden nails and cladding in wood.

Process
From the beginning, the rules of the Hopsjø workshop were clear. A programme for a multipurpose protection shed at the harbour to be finished within nine days. The building site was a 2,4 × 20 m concrete slab floor, made by locals before arrival. The process was in two main steps.

The workshop started with a competition among students in drawings and models. The winning project was a sketch, and this sketch became the only document for the whole working process and the final built project.

Learning carpentry was important in the workshop. Details were not developed before the start of construction, but during the construction process. This means that the aesthetics of the project were not represented in drawings, but were developed and expressed during the process of constructing[2].

Case study II – A sauna in Vang BADSTU

Valdres is a region in the east of Norway, extending northwards towards the west coast over the mountains. The settlement was founded on agriculture, hunting and forestry, and is famous for local traditions in music, artisan craft and building culture. Vang, with its 1600 inhabitants, has a new growing culture of young entrepreneurship.

On 12 April 2015, fifteen students from all over Europe arrived at the factory Norsk Missivtre AS at Begna in Valdres. All were students in the master's course Topology, Typology and Tectonics. The course aims to develop a tectonic and a site-specific approach to architecture. It is about a basic understanding of architecture and about the global environmental and social challenges of our time and investigates the meaning of the use of local resources. The question might seem controversial at a time when architecture and construction technology seem to be more concerned with the use of materials from all over the globe, neglecting the values of the near surroundings. The course discusses how global and local understanding can enrich one other in a dualistic relationship: the meaning of the local in the global and the global in the local. On 22 April the sauna, called BADSTU, was inaugurated and handed over to the population of Vang and Valdres.

Materials

All of the materials used in the sauna project were local. The main material was spruce from Begna Bruk, the local sawmill and supplier of wood to Norsk Massivtre located 500 m away. Begna Bruk runs equipment in its line of production that can sort sawn timber by quality, including slow-grown spruce for cladding. Wooden elements of nine stacked and screwed 2 × 4 inch planks. Cladding: 1 × 3 and 1 × 4 inch panels.

2 The Norwegian painter Kjell Nupen was commissioned to make a big glass painting for the new church in Søm in Norway in 2004. He is famous for his colourful abstract paintings. The glass painting was produced in a workshop in Copenhagen. In an interview he said that he first arrived at the workshop with drawings of the whole painting. After a while he discovered that this did not work, because the drawing became a barrier between him and the painting. Then he made the glass painting 'spontaneously', directly on the glass in the workshop.

Tools
- Traverse crane
- One jig – a production table
- Electric drill, saw and plane

Concept
The cladding used for the sauna consists of overlapping panels of slow-grown spruce, custom planed in 1 × 3 and 1 × 4 inch panels from the sawmill. The main structure is made of the stacked wood element of Norsk Massivtre, which was further developed and adapted by the students. The stacked wood element consists of nine stacked 2 × 4 inch planks, screwed together by 40 cm screws. The elements can be connected with screws to become wall units.

Process
The whole process before the sauna was finally built was divided into four phases and started with a visit to the area and factory, to learn and experiment. From a design competition in groups of students, one project was chosen to be built. All fifteen students cooperated in developing details and planning the construction of the sauna. Complete computer-based production drawings were produced. Based on the drawings, with millimetre precision, construction at the factory took place, followed by mounting and cladding the sauna on site. It took seven days to prefabricate and assemble the massive wood elements in the production hall of Norsk Massivtre AS. The prefabricated elements were put together and clad during the final three days on site.

The whole process provided many levels of theoretical and experienced knowledge. The development of the architectural ideas and the tectonics of the sauna was mainly defined and agreed before the construction process represented by the computer drawing

Location
The locations of the two workshops are interesting, and this seems to have an important influence on many levels. This does not mean that one or the other building culture is more tectonic. They are different, and it seems as though the two workshops reflect this understanding.

Hopsjø is located on a remote island of Europe, a place with an overwhelming presence of the sea and the horizon, in an open horizontal landscape. It is a small and concentrated population situated around a harbour and the richness of the sea, with limited access to forest and wooden materials. The building culture is based on structural systems with a very economical use of wood.

Vang is located in a high and mountainous part of Europe, in a long and deep valley, a landscape dominated by its verticality. This area, with good access to wooden materials, has developed log structures as its main building tradition. The richness of wooden materials has led to the development of a local wood-based industry.

A comparison between these two locations makes it easy to see the different backgrounds for their tectonics. Hopsjø represents a low-tech culture and a direct connection between the idea of constructing and making. In Vang, by contrast, a more industrial culture has developed within building industry. This also means that more levels of decisions exist between the idea of architecture and the act of construction.

When building at scale 1:1 at a certain location, it is important to be aware of the knowledge and experiences belonging to a culture, the Episteme.

Process

The processes of the two workshops differed in two respects. One was the cultural difference between the two locations. The other was that the Erasmus IP workshop at Hopsjø was an intense two-week meeting, while the sauna in Vang was part of a half-year master's study at the university.

In the case of Hopsjø, it seems that Techne became the dominant driving force, while Episteme and Phronesis became more like silent servants. This means the process was close to what Richard Sennett describes as the craftsman's way of thinking, to wait to solve problems until they arrive. In the case of Vang, the picture was different because the whole process of constructing was split up on many different levels that had different didactic meanings. One was gaining scientific knowledge about materials and production, the Episteme. Another was experimenting by making and breaking rules at all scales, making new meanings, here understood as the Pronesis. The act of constructing was linked to gain knowledge of materials, the construction systems and the processes needed to realize the aesthetics of the sauna, the Techne.

Tectonic ideas
The tectonic ideas behind the two projects differed and were represented in different ways. In Hopsjø the simplest representation of the idea was a cross-section on one piece of paper. In Vang it was a 1:1 sketch model of a finger joint.

The investigation shows there is an important relationship between the locations where construction work takes place, the tectonic concepts and the resulting educational benefits. The two cases show a certain distinction within teaching and learning.

Didactic concept A
In the case of Hopsjø, as a type of a didactic concept, it seems that the limited palette of available local materials, and the lack of investment in planning and design before construction, might create a close and direct contact with the materials. It also seems that this directness engaged the students and opened them to both practical and haptic experiences in a one-to-one relation with the actual materials. That resulted in a fast and dynamic learning-by-doing process, also when it came to cooperating in a construction process. The learning here is basically to create an understanding of tectonics in architecture. The teaching of the craftsman, on the other hand, can easily risk being conservative and neglecting an experimental approach to architecture.

Didactic concept B
The case of Vang, as a didactic concept, is different. It seems that an experimental approach is easy and welcome for the local industrial culture. The construction process was efficient, and all solutions were already solved by heavy work at the studio at NTNU.

This way of teaching to some extent mimics the practice of architecture and isa preparation for life outside the university.

The understanding of tectonics here extends to include the notion of industrial learning, production, building systems and logistics.

Concrete versus abstraction
When teaching architecture in a university studio, one often distinguishes between teaching basic knowledge, general knowledge applicable in many situations out of time and place, and teaching what is demanded by the

profession outside university. These two poles are also reflected when it comes to teaching construction at scale 1:1. Building at 1:1 is a sensual experience which cannot be contained in an architectural drawing, while designing in the studio has a more abstract character. Bringing these two qualities together in a situation where they can inform and develop each other seems to be the didactic challenge.

Learning from locations

Learning from the two cases, I think we overlook potential. This concern is about the deep relationship between a built structure and the location in which it is built. A location will always represent a culture, climate, nature, human life and much more. This relation between the location and built architecture at scale 1:1 seems to have strongly guided the teaching, consciously or unconsciously. For this reason, it is important to exploit the learning potential of building at full scale.

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Listening to the material. An intuitive approach to the knowledge of construction materials

> *All materials have their own non-written laws. This is forgotten far too often. You should never be violent with the material you're working on, and the designer should aim at being in harmony with his material [...]. The craftsman has the advantage that, through all the phases of his work, his material is in his hands for him to feel it and lead it.* (Tapio Wirkkala. 1980)

Throughout the 20th Century, student engineers and architects traditionally learned about materials and components of construction by wading through tiresome books dense with detailed descriptions of each component: its natural or synthetic origin, its molecular structure, the processes involved in its manufacture, lists of its physical and chemical properties, and the by-products and derivatives that it could give rise to. This was, and still is nowadays, a very necessary but very "external" learning process, which imposes a certain distance from these materials (a distance that all intellectual learning imposes).

The Intensive Program Tectonics in Building Culture proposed a more intimate learning process, in order to establish a closer relationship between the material and the person handling it. The program aimed to explore how it is this very handling (manipulating with the hands) that makes this dialogue between material and learner possible.

> *The hands are the sculptor's eyes; but they are also organs for thought [...] The skin reads the texture, weight, density and temperature of matter.* (J. Pallasmaa 2005).

The materials studied in the last 10 years are: wood (in its different shapes: boards, massive wood and wicker), clay (bricks), concrete and steel. The simplest processes of handling initially revealed the most obvious properties of solids that can affect our senses: sight (colour, sheen), touch (texture and roughness, but also the temperature of the material and therefore its thermal conductance), its sonority, and why not its taste. In subsequent, more sophisticated, handling such as cutting, splitting, folding, or simply placing, we began to discover aspects related to the internal structure of the material such as its isotropy or its anisotropy, as well as its main physical characteristics like density, porosity, hardness, and elasticity, and we achieved an initial feeling related to its capacity for resistance. A simple observation of how the material reacted to the environment in which it was handled provided an insight into its most immediate and basic chemical reactions to water or air.

It is clear that learning about the characteristics of the components of construction in this way is primordially intuitive, but this does not by any means invalidate the resulting knowledge. The aim was for this dialogue between material and handler to bring about the discovery of the most "natural" way to treat the material. This meant the most efficient way, and thus required a deep knowledge of the material involved. [→ Fig. 1–6, 7–8]

The weight of the stones that we worked with in the workshop in Ireland, the difficulties inherent in handling them, the slow pace of construction, and the robustness of the resulting structures, all provided a sharp contrast to the experience of wicker in Gdansk (Poland). Wicker is lightweight and easy to handle; it is very elastic and takes form easily. It was easy to try things out, to make models and small structures that threatened to take over the workspace. Likewise, this experience of wicker was a contrast to the experience of working with fine steel rods in Barcelona (Spain). The wicker and the steel rods shared a similar format, and the same techniques could be used to give them shape, but it became immediately apparent that the wild nature of steel would resist any subsequent attempts at altering this shape: it was too rigid, too hard. In fact, we needed to manufacture tools to help us tame this wild material to a workable level.

The second discovery came when handling transcended the simple material or component of construction to create an architectonic construction, which meant a stable structure large enough to give shelter to any human activity. Making bigger, taller, thicker structures was an all-pervasive goal throughout our workshops.

This transformation process of the simple and small-scale material to a bigger, more complex system revealed the construction and structural laws of the building technique associated to each specific material. The handling here was based on piling, as in the structures made of stone materials (Ireland), clay (Holland), and massive wood (Liechtenstein). Students also experienced making filigree and weaving with wicker (Poland), working with steel rods (Spain), and with timber framing (Norway). They experienced folding with wooden boards (in Belgium), and finally, moulding concrete (Denmark). [→ Fig. 9–11, 12–16, 17–19]

Each of these techniques was practised intuitively right from the beginning of the workshop, so that students handled the material and experienced the techniques at

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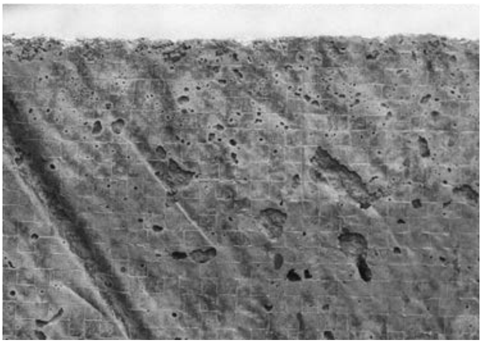

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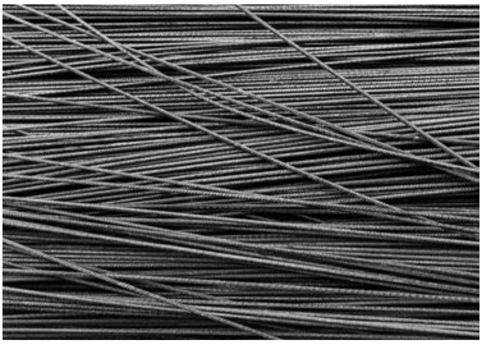

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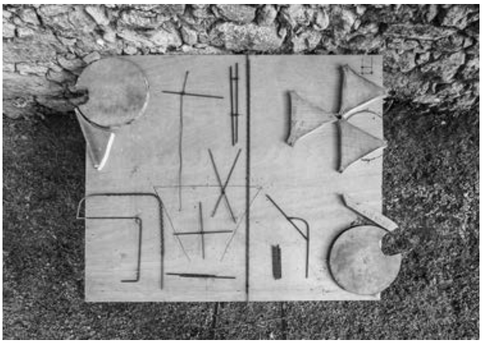
1–6 Materials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7–8 Wicker vs. steel
9–11 Techniques

the most elemental level, thus enabling them to discover the central idea of the technique for themselves, which is the joint. They investigated the potential of each material to be joined with another. The learner's unspoilt mind looked, once again, for the most efficient way of working each material. The steel rods (6 mm in diameter) in Barcelona were subjected to traction, compression and bowing, all essential tests for the coherent design of joints and the endless struggle to stop the thin walls of the constructions from sagging. It was interesting to observe the variety of different solutions that students proposed, having worked so intuitively on the material.

There was no theory, just a couple of basic indications of how to handle the material, some tools, and the necessary safety instructions. And to compensate for this, there were no time limits. The workshops were by definition an intensification of a very specific case study, so there had to be enough time for the learners to immerse themselves in the topic at hand. Enough time to get things wrong and to try again and again until the learners found their own satisfactory solution.

The third discovery was the response to our concern as human beings to seek beauty in any activity that we undertake. As architects, we are especially aware of this aspect of building, without leaving aside the previous points made about the personal characteristics of materials. The third question we were seeking to answer in this dialogue was how, in its transformation process, could our construction material reach its maximum tectonic potential? In other words, how could we make each construction beautiful?

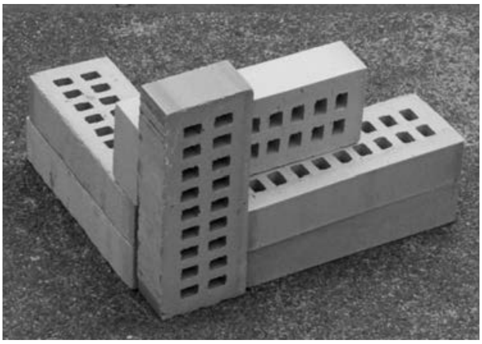
On the one hand, the beauty of any construction can be found, as in nature or in traditional architecture, in its efficiency. We can agree that nature is beautiful because nothing is superfluous. Efficiency is a very important concept in the world today, given the environmental challenges we are immersed in.

On the other hand, each material and each component should be used in the very contexts that allow them to fully express their natural characteristics and thus bring out the best in each one.

In Holland, the task was simply to stack bricks, an apparently straightforward task. Each group of students had a different model and amount of bricks, and they had to stack them. The aim was not only to create a balanced structure, but also to find a way of combining all the individual units to create a whole that was the maximum expression of the sum of all its parts. To make this possible, the students found that they had to try over and over again to create their structure, each time getting closer to the "perfect" solution (the one that the student was looking for). The result was a series of very different constructions, just as the bricks that each group was working with were very different, that reflected the intense research involved in the creation process.

There was one final learning process, by no means less important than the others, implicit in how the dialogue evolved between material and handler. I understand there to be three key aspects involved. [→ Fig. 20–22, 23–25]

The first is the simultaneity of thought in the creative design process. A quality often attributed to architects, and that we are taught to develop, is the ability to visualise a problem globally and to contextualise it, and we are expected to offer responses based on this principle. On the other hand, we have to be able to create very complex systems that take into account many very real conditioning factors at the same time. This is a difficult ability to teach because we often try to separate knowledge into convenient compartments that become too limiting. The success of the overall results (the design) depends on how effectively the project integrates its responses to these conditioning factors, on how global its solutions are. The truth is that in this dialogue between handler and material, between learner and knowledge, the learning processes that have been explained separately and successively do not, in fact, happen in this way, but rather they take place simultaneously and randomly, thereby making the learning process much more complex, rich, and, above all, real. The workshop in Belgium serves as an example. Learners worked with both OSB boards and plywood boards, 1 cm thick and the standard 244 × 122 cm length and width. Each group of learners had to build a structure that was larger than the original measurements of the boards, in a specific place. This was a standard procedure in all our workshops: first, the learners undertook an experiential process of getting to know the material, and then they deepened this knowledge with broader, more complex tasks. In order to build a balanced and stable structure in this workshop, the learners had to understand the mechanisms involved in each step, and they therefore had to understand the material they were working with. However,



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12–16 Joints

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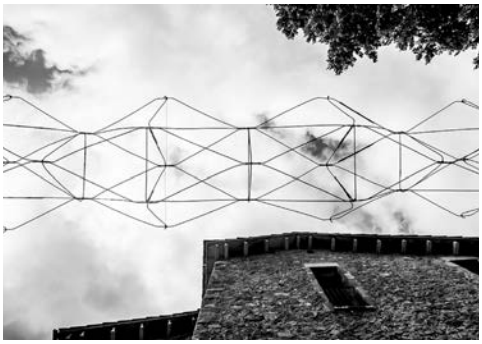

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17–19 Steel constructions
20–22 Reaching a perfect structure

they also had to estimate the amount of wood and secondary materials they would need, which meant studying which and what type of modular units would be required in order to minimize waste. Alongside this, the learners also had to produce a work plan that planned for all 8 participants being involved in the construction process at the same time, they had to solve logistical problems, such as getting the material onto a site with difficult access, or how to place materials onto the highest parts of the construction, all according to the group's particular project. Some of these decisions may seem unrelated, but they were all given equal priority in this workshop. [→ Fig. 26–28]

The second key aspect that makes learning more complete in this process is the rigour imposed by working with reality. All teaching, and especially university teaching, is based on abstract theory, which is what makes it university teaching and not vocational training. Yet this does not mean that our profession, or arguably our trade, does not require practical learning and contact with reality. Perhaps the most emblematic case was the work carried out in Liechtenstein with massive wood, where we had real clients and real regulations that had to be followed, and where our work experience project would actually become part of several families' weekend retreats! The game was absolutely real, and several equally important requirements had to be taken into account, such as stability, and the waterproof qualities and durability of the wood, amongst others. Organisation was of paramount importance in this workshop as timing was an important deciding factor. A properly organised working space was essential: storage area, preparation area, and building area; and the effective organisation of teams and work tempos was vital to the project's success. It is obvious that reality comes into play in all areas of such a project, not just those described. For example, a significant conditioning factor related strictly to this workshop, was that of dimensional coordination. This factor was particularly present in this project, as strict legal regulations existed with regard to the height of the structure, and the wall (the objective of the project) was to be just one of several systems that would form the structure as a whole. *I have not failed, not once. I've discovered ten thousand ways that don't work.* (Thomas A. Edison). The third key aspect implicit in how the material-handler dialogue is produced, is failure. Learning is based on the learner handling and experiencing the material, and so it is a method based on trial and error. Only through successive failure can the perfect solution be reached, as the bricks workshop in Holland showed. The dialogue proves itself truthful, and thus leads to the success of the experience. Sometimes, a group may have stopped halfway through an exercise, but this does not mean that the level of learning has done likewise. On the contrary: success is found on the journey already made.

It would be hard for our schools to incorporate this type of learning experience on a regular basis, as they often have to race at a tremendous pace through dense, rigidly compartmentalised curriculums that are perhaps often too theoretical. In this context, having time for reflection is, unfortunately, an all-too elusive luxury. And reflection is precisely what this article aims to discuss. In the words of the architect, J. Pallasmaa (2005):

> *It is obvious that we need an educational change with regard to the sensory sphere, for us to discover ourselves again as physical and mental beings in order to fully use our capabilities and become less vulnerable to manipulation and exploitation.*

Architecture needs moments of reflection like the ones detailed in this article. Only in this way can our profession work with a sense of its real limits, and deepen its knowledge in a genuine and meaningful way.

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Photographs in Holland (bricks): Jeroen Mush and Raimon Farré; Ireland (stones): Caludi Aguiló; Denmark (concrete): students and teachers; Belgium (boards): Ingrid Boxus and Raimon Farré; Spain (steel): Andrés Flasjszer and Raimon Farré; Liechtenstein (massive wood): Raimon Farré and Marta Besora.


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23–25 Thinking the process
26–28 Working with reality

Material, structure, tectonics: the power of full scale in the education of architects

Material and structure are basic terms in architecture, easy to describe and permanently used in the debate about the profession. But how do we offer our students a way to understand the meaning of tectonics? According to Eduard Sekler, structure as an abstract term is materialized with construction, but only tectonics has the potential to make the two legible. In other words: the raw and innocent material needs a structural idea in order to develop a consistent form, but with the tectonic approach, the architect is able to inscribe meaning into it. Designing does not stop at the point where manufacturing begins. Moreover, it almost never ends until the last member of the construction is set into place. This perpetual aspect is a main concern in the cultivation of a tectonic approach in architecture. Working at full scale at the University of Liechtenstein, as well as in European workshops, over the past ten years contributed to the discourse about tectonics in the teaching of architecture in Europe.

Construction as a driving force: Ludwig Mies van der Rohe, Lake Shore Drive Apartments, Chicago

The weight of the construction

Designing architecture is not a linear matter. How can we get the creative process going? Where does inspiration come from? Can architecture be derived from just a single sketch? Anyone acquainted with our profession knows that the frequently employed bon mot that designing requires 'more perspiration than inspiration' did not appear out of thin air, and that flashes of architectural inspiration are not to be trusted. Rather, the structure of architectural training which we call construction – the rendering of thoughts into buildings – requires a solid foundation. Three terms can serve to provide students with an introduction to the profession of construction: materials, structures and tectonics. The three terms can be examined in the most differing ways and, in order to complete the mosaic of the professional profile, they need to be repeatedly returned to throughout the course of training. Nevertheless, one particular route into the cosmos of tectonics would be the one that uses a physical involvement with materials at scale 1:1 as its point of departure.

Eduard Sekler, who has published books on Le Corbusier, Josef Hoffmann, and the architectural design process in general, has brought considerable clarity to this thicket of terms in a remarkable essay, using a kind of triangulation:

> *STRUCTURE as a principle and immanent order is materialized by CONSTRUCTION, but only TECTONICS make structure and construction artistically visible and endows them with expression.* (Sekler 1967).

The drama of support and load processed into a pure tectonic expression: Mies van der Rohe, corner detail, Chicago

As an example he mentions Mies van der Rohe's curtain-wall façades, in which the image of construction is made manifest. Even though the steel struts of the glass façade have little relevance for a building's overall construction, they nevertheless elucidate its steel-frame structure. The struts of the façade are not required to stand on the ground, since they solely serve the façade's construction, guaranteeing its stability. They are supported by the floor slabs, and demonstrate in the soffit, and particularly in the corner design, their tectonic character as a curtain, as a hung surface. The drama of support and load becomes a curtain and is completely comprehensible through the externally mounted struts. Tectonics here therefore becomes the art of joining parts.

The innocence of the materials

In seeking the laws of the art of construction, we have to begin with the individual parts. If the architectural product constitutes what has been created and is constructed from pro = for and ducere = lead, then it is the architect's responsibility to guide the origins to the actual thing. However, the innocence of the materials does not exist. The materials that we in our profession usually refer to as raw materials have always already gone through an entire production process which has been initiated with a particular objective in mind. The intention of extracting, felling, or generally harvesting leads to the first step of processing and half the way to the final result. Clay is extracted, refined, mixed with sand to form a compound which is malleable, and pressed into brick forms. The raw tree trunk is felled, delimbed, transported, stored, and finally cut into planks and beams or shaved into veneers which can be further processed into plywood panels. The materials that architects work with are therefore already based on a kind of processing, further exploitation being more or less inscribed. Our own intention, however, has been to travel this predetermined route with innocent eyes. How can what we have in our hands be read as the point zero of construction – le degré zéro de la construction – in order to arrive at new methods of production?

Apart from design know-how – the development of the floor plan, section and elevation of a building, and the sculptural development of the structural shell – the student has to be aware, from the very beginning, of what the bricklayer, carpenter and metalworker will be doing on the building site. We do not understand materials as a means of realizing formal concepts – as is advocated by contemporary Anglo-American architecture. Instead, they are already vehicles of potential expression. The materials do not clad the architectural form, but the form is derived from the materials. Materials represent the vocabulary of architecture which, in its own grammar, seeks formulation in a meaningful and consequently tectonic structure. What force can the materials emit in their ‘raw’ state? And why should we not use this energy as the fuel for design?

In architectural instruction at scale 1:1, a key tool is a direct confrontation with the materials during the design process. To create from the specifics of the materials means actually touching them, working on them with your hands and your own strength, and positioning them in relation to one’s own body. Juhani Pallasmaa emphasized touching, in his essays, as a prehistoric human skill which has been forgotten and that we should not lose, formulating his understanding of the profession of the architect as follows:

> *…I do all kinds of things. I have been a farmhand, a construction worker, an administrator, a university rector, a graphic and product designer, etc… but I do everything through an architect’s eyes and mindset. However, I don’t mean architect as a professional, but as an archetype, a ‘-smith’, as it were. A blacksmith would not be a professional, but almost a mythical person. In the same way I regard an architect as a supporter of the mythical dimensions of life, not a professionalist.* (Pallasmaa 2011).

The architect’s physical relationship to things is essential in generating new possibilities. Materials are raw instruments that need to be made to resonate. Consequently, the decisive factor is not preconceived skills in handling and processing materials, but skills that have been developed by doing. It is nevertheless dedication that will determine the quality of the resonance, the soul of the sound. This means that curiosity is more important than perfection in execution. It is therefore not important whether students have some prior knowledge of processing particular materials, or if they are encountering them completely innocently.

A tectonic shed: Erasmus IP 2007, Hopsjø, Norway

Structure

The concept of structure, as used by Eduard Sekler, is abstract. Architecture’s structural elements, such as pillars, arches and frame construction, are assembled via an appropriate use of resources. A whole emerges when the laws of tectonics are obeyed and the author can supply sufficient creative powers. However, if we begin from the materials, the structure becomes the tamer of the wild energy of the raw. *The brick says: I want an arch.* Louis Kahn's famous dialogue with the brick encapsulates the claim, or even the necessity, *to listen to the materials.* (Kahn 2003). The structure is then required to guarantee that the materials form a meaningful combination. The materials seek particular things in order to be able to unfold their force, to be heard. Structure in this sense represents the possibilities of combining, the assembling of components. This ultimately generates a tectonic interplay of components which becomes a whole, just as words can become a text. The building components are not merely positioned on top or next to each other but are joined. It is no coincidence that the term tectonics derives from *tekton*, the Greek word for carpenter.

From clay to brick: Erasmus IP 2008, Zeddam, The Netherlands

The art of joining mediates from the component to the whole, from the thing to the structure. To create the joint from the material itself is one of the most obvious, but frequently also most demanding possibilities along the route to what is built. Braiding and weaving lend themselves to many materials. Originally techniques in textiles, they provide a wide range of variations, with which we are already acquainted, from the field of clothing and fashion for example. Interestingly, however, it is not only willow branches that can be woven – an obvious technique – but with some imagination the same can be done with plywood strips, and iron rods too can also be woven. A woven wall structure can even be created using bricks, one which would have textile qualities, without actually being a textile.

The weight of the material: Erasmus IP 2009, Letterfrack, Ireland

Two educational concepts

The logical use of building materials, tectonic placing, and the forms deriving from materials are today no longer traditionally available in existing architecture, and consequently are no longer automatically found in architectural training. The origin of this development derives from the beginnings of industrialization in the 18th century and consequently in Victorian England, the transition from craft to technology-based mechanical production. This allowed, for the first time, the serial processing of such traditional materials as stone, brick and wood, and enabled the development of new building materials such as steel, cast iron and concrete. As a result of scientific advances, the behaviour of building materials could be precisely calculated, the building components scaled accordingly, and their use defined. This innovative, scientifically based management of materials and the calculations of load capacity deriving from it, in combination with new means of employing them, resulted in the loss of the art of tectonics as well as the dividing of architecture into the separate areas of construction and design.

Textile concrete: Erasmus IP 2010, Bornhølm, Denmark

This division was further reinforced in the late 18th century, beginning in France and consequently throughout Europe, whereby two different directions within architectural training offered contrasting curricula. The École des Beaux Arts, operating wholly within the spirit of previous centuries, began receiving competition around 1794/95 from the new École Polytechnique, whose first tutor of architecture was Jean-Nicolas-Louis Durand. Whilst the training at the École des Beaux Arts mainly addressed the design issue of which building styles from the past were to be employed in the buildings to be realized by its students, the École Polytechnique taught scientific innovations in construction, explored new materials, and experimented with new construction methods, which fuelled a diversification into specializations.

What both educational concepts had in common was that they did not generate design from the logic of joined materials, but reduced this area to a decorative function independent of construction, in the form of ornamentation and adornment. To show or hide, to conceal or reveal the construction, suddenly became the key issue, the major theme of 19th century architectural theory. This was a subject that Karl Bötticher had already examined in his publication *The Tectonics of the Hellenes* (Bötticher 1874), a meaningful relationship between materials and structure being already of importance to him at that time. Likewise the architect Gottfried Semper also noted in *Style in the Technical and Tectonic Arts* that the masking of building materials could be eschewed. Only complete technical perfection, a well-understood and proper treatment of the materials in accordance with their properties, and above all a consideration of the latter, in the design process itself, would enable us to forget the materials. (Semper 1878)

Eugène Viollet-le-Duc, too, foregrounded mature construction and its architectural visualization, additionally advocating the development of a new building style, which was to once again reunite the two areas of construction and design. Nevertheless, the majority of design aspects were not derived from the logic of joined materials, but were mostly applied latterly in the form of décor and ornament. The theoretical basis for the subsequent rejection of and critical dispute with ornament and its eventual dissolution was to be found in critiques of industrial fabrication together with the productivist and technological paradigm shift from craft to industry, as advanced by Georg Simmel, Walter Benjamin and Siegfried Kracauer, as well as in the lecture 'Ornament und Verbrechen' (Ornament and Crime) by Adolf Loos. Even today the term 'ornament' still predominantly implies the negative connotation of the 19th century and the proscribing of modernism. It is therefore not often used in contemporary architecture, being increasingly replaced by other names, such as pattern, structure or texture.

Changing economic conditions, new building materials and construction methods, as well as numerous new political and social conditions, had – in modernism's global victory and subsequent functionalism – a momentous influence on the interplay of the areas of construction and design in architecture, which led to an ongoing divided approach to them until the second half of the 20th century. The two educational concepts, the focus at the École Polytechnique on the increasing technical issues and the physics of construction, and the formal and artistic ones at the École des Beaux Arts, further intensified this trend.

Lightness in wood: Erasmus IP 2011, Amay, Belgium

The art of joining

Due to this development in the architectural world, the art of joining components which have to fulfil differing functions, to create a new sum, is today closer to many artists than to contemporary architecture. This is especially the case in works from Minimal Art, Pop Art and Land Art which have emerged since the 1960s. As early as 1964, the artist Carl Andre created the sculptural work Cedar Piece, which comprised the serial tectonic joining of solid wooden beams, an artistic metaphor for the assembling of materials into a new whole, and which remains valid for the architectural world until today. Likewise, the Danish artist Per Kirkeby addressed the northern European tradition of serially joining bricks, at a time when this material was no longer being employed by architects.

In this context it is not surprising that the logic of joined materials was only to regain significance at the beginning of the 21st century, and now arises frequently in architecture. Surface decoration that is unrelated to construction is currently leading to an interesting discussion – one already undertaken in the 19th century – as numerous exhibitions, symposiums, articles in such architectural journals as the 'Neue Ornamente' issue of *Archithese*, and various literary contributions testify. There are virtually no limits in experimenting with materials, and the creative expression of construction once again increasingly arises from constructive considerations and forms resulting from the materials. Christopher Alexander, writing in his book *A Pattern Language*, noted that design elements should not arise from natural exuberance and a tendency to create something cheerful, but from a function that is as clear and unequivocal as any other function in a building. (Alexander 1995)

Wicker weaving: Erasmus IP 2012, Sztutowo, Poland

Since Semper's architectural theories, the cladding of architecture has been a fact. For him, architecture arises from tectonic joining that in turn had been derived from the art of carpentry, a route from joining to a new whole, which under the concept of tectonics unites construction, art and technology. In contrast to architects who were trained in the 19th century, a knowledge of craft and design traditions was no longer taught in the training centres of the 20th century, and consequently also played a subordinate role in the world of architecture. And this is precisely where we are beginning again with our architectural training. Making at scale 1:1, and the influence of the 'working hand', as Juhani Pallasmaa described it, has again become a significant factor. For this reason, we have in recent years, at the University of Liechtenstein, increasingly focused on experimenting at scale 1:1, on becoming familiar with various materials and their specific properties, and integrating these into our architectural training.

Making at full scale

The Erasmus Intensive Programmes series allows European students to become acquainted with a variety of materials in annually changing regional contexts. The two-week workshops have always been built around the same didactic approach: in the first week, short experiments were conducted with materials, such as brick, wood or concrete. These series of experiments had the objective of familiarizing participants with the properties and specifics of the materials at scale 1:1, and the realization of a design task in the second week, departing from a tectonic joining of materials that combined both constructive and design aspects. The making at scale 1:1, such as stacking bricks, joining wood and casting concrete, was at the core of the Erasmus Intensive Programmes series. To document our experiences and built examples, each Erasmus Intensive Programme was summarized in a booklet. The series of booklets enriches the making at scale 1:1 with written reflections and offers the possibility of bringing back experiences of the logic of the material into the academic world of our European partner schools. The Erasmus Intensive Programmes that have been conducted very consciously offered the potential of raising and spreading awareness of the diversity of cultural heritage of building that exists in Europe, linking it again to academic curricula – achieving, so to speak, a hybrid of the Ecole des Beaux Arts and the Ecole Polytechnique, by combining the materials' technical laws with design elements – the points of focus for the two training methods.

Bending steel bars: Erasmus IP 2013, Vidrà, Spain

We went one step further for our 'Loipahötta' design studio when, for a design assignment lasting throughout the 2012 summer semester, we developed a cross-country skiing cabin as a joined structure, beginning from a single piece of wood and subsequently realizing the building with students on location in the Liechtenstein mountains. The tectonic placing of the wooden slats determined the appearance and character of the cabin, both in terms of construction and design. For the 'Radical Inn' design studio in the summer semester of 2013, a design for a hotel in Amsterdam, which we realized together with the Amsterdam Academy of Architecture, the design assignment involved the tectonic joining of bricks. To start with, in a two-day workshop, the Dutch and Liechtenstein students jointly constructed a wall with an opening at scale 1:1, using the material logic of bricks. These tectonic structures were subsequently drawn by the students, enabling them to be reconsidered. In a further step in the exercise, a tectonically joined staircase, column and wall opening followed. Through the combination of individual steps in the 1:1 experiment, the students developed the assignment from the brick, to the pile, to the support, to the building structure. In this manner they designed the building from the logic of the materials from the inside to the outside, a whole emerging from the part.

The positive experiences during the Erasmus Intensive Programmes series and the design studios led to a continuation in the new Erasmus+ programme component 'Crafting the Façade', in collaboration with the Amsterdam

Academy of Architecture and the Mackintosh School of Architecture in Glasgow, which enables us to thoroughly address the issues of materials, structure and tectonics, combining it with the approach of making at scale 1:1, and to provide it once again with more of a foothold in architectural training and consequently its long-term reintroduction into architecture itself.

The tectonic approach

What then is the core of tectonics? This can be answered once again using Sekler: structure refers to the arrangement of components in an organizational principle. By contrast, construction means the conscious activity of assembling to achieve the realization of a system, using a variety of materials. It is only tectonics, however, that can provide us with the tools to make the play of forces within the structure and the arrangement of components legible, and this struggle between weight and rigidity within the building generates 'expression' – a result of that more general artistic activity of 'making visible' in Paul Klee's sense. In order to strengthen construction in architecture, a focus on integrating the materials at scale 1:1 is crucial. By emphasizing doing and production, we have attempted to generate an understanding of tectonics as an approach to the art of building via practical activity. We therefore understand tectonics less as a theoretical discipline, and more as a bridge for the maker between action and reflection. This is in keeping with the 'making visible' of forces, Paul Klee's attempt to explain the magic of images as being the result of a complex process.

Two didactic concepts can be observed in the art of joining. On the one hand an incredible wealth of traditional ways of joining already exists, for example in the European art of carpentry, the highly artificial Japanese art of joining wood, and knowledge concerning the assembling of wooden components, collected in the Chinese yingzao fashi construction manual. To learn from these, particularly as an architect who is not a craftsperson, as a generalist, or as Pallasmaa describes it, as a *supporter of the mythical dimension* (Pallasmaa 2001), represents an extremely interesting opportunity to discover something new through experimentation. The most meaningful nodes frequently arise from sheer lack of knowledge, fuelled by a dilettante's hazy notions and curiosity, with a structural multiplication evolving into completely new

Inserting a part to an alpine settlement: Erasmus IP 2014, Tuass, Liechtenstein constellations. The Erasmus Intensive Programmes conducted in the last ten years have been rich in such discoveries, which have emerged from an almost naïve search. The two routes to insight, however, are by no means exclusive and can be applied concurrently during training, as is frequently the case in the first-year course at the University of Liechtenstein. It is frequently possible to generate a new kind of energy from the tension between the two concepts that can then fuel the design.

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Tools, Techniques and Apparatus

This text is one of a set of texts by different authors, engaging with issues that emerged within the environment of 'design by making' workshops with students in architecture. They all investigate specific aspects of building at full scale as an educational tool for teaching and learning architecture. The overall aim of the workshops, held together by the common denominator 'Tectonics/ Structures in Building Culture', is to learn architecture from within practices of making, in which one engages in design and construction at scale one to one, with one type of material. The architectural projects have to be developed from the material itself and from direct physical engagement with it. In other words, from the actions of manipulation and transformation of the material itself and not from predetermined ideation. The technical operations of shaping, cutting, assembling, arranging, joining and so forth, are required to be more than instrumental, given that they have to be explorative and designerly actions too. Therefore, the construction process duly has to become a design process, one that is not remote from the execution of the work, but integral to it.

The purpose of this text is to highlight the role played, within this endeavour, by *the means whereby a specific production is made existent or a task accomplished* (Wiktionary, accessed on 14 Dec 2015), or in one word, the 'apparatus'. The etymology of the term indicates that it embodies both an orientation towards an end, as well as a preparation or a making ready for that end. More precisely, and applied to our context, one can say that the notion of 'apparatus' refers to a 'construction of means', in the sense of a setting-up of a complex of resources, i.e. the things collectively necessary for the performance of some activity and the equipment used in doing it, as well as the activation of them. That is what the title of this text, 'Constructing Things for Constructing other Things', explicitly refers to, namely, the careful elaboration and making operative of the means needed for reaching the ends that we have set ourselves. The tools and the techniques used for bringing the whole set-up into operation are intricate to the notion of apparatus. Within the lines that follow, I will develop my argument starting from tools and I will move gradually towards the more comprehensive theme of apparatus. For this purpose I will use some examples of how it unfolded within the activities of learning architecture by making it at full scale.

The apparatus incorporates a process of becoming along with the procedures and operational sequences that compose and define that process. Creating an apparatus induces a reflection upon this process and the different roles the apparatus has to play. It needs to embody a capacity to mediate between material and manipulation, between process and result, between movement and statics, and between idea and action in making. The dialectical relations incorporated within apparatus (between set-up, techniques and tools) determine the thing that is made with it, but conversely its character is itself determined by that very thing, at least when it is created from the qualities it anticipates upon.

Means and Ends
For all workshops the unambiguously stated end, presented to and required of the students, is the construction of architectural artefacts at full scale, or in other words, built works. But since the underlying goal is learning, the initiating process is of the utmost importance and we need to consider it as an end in itself, with its activities, its doings and both the experiences and material results that are produced within it, as distinct from the architectural end result. The built artefact that closes off the process is therefore an end for sure, but also a kind of alibi, or rather, an incentive that is needed to drive the process, to keep it going, to give it a tangible goal to move towards and to keep the actors within it motivated and engaged. Seen from this perspective, the architectural artefact is something that also articulates and embodies the successes and failures that were part and parcel of the process of development and construction.

Conversely, apparatus and its assortment of tools and techniques are commonly seen as 'means' to an end. Almost invariably and by definition they refer to, and are incorporated in, the technical practices or activities that initiate and ultimately lead to a thing being made, but not to that very thing itself. In this sense apparatus, tools and techniques are instrumental, i.e. instruments and operations by which an intended result is brought about. They need to serve the end and have to contain capacities that help to achieve it, which is another way of saying that they must be useful, efficient and performative. I reckon that most of us would consider this to be their most relevant asset, namely the potential to be used for what they were meant to, for achieving a strictly defined goal. The statement that *tools shape materials that make forms, not the other way around* (Barkow Leibinger 2009, p.1), is a common example of this stance, and by analogy, it can be extended to incorporate or apply to apparatus as well.

Unfortunately though, this way of seeing reduces both the notion of tool and apparatus to use, downstream of their coming into existence, and it tends to limit our role to that of an end-user. For instance, seeing tools as something *ready-to-hand* (Heidegger), ready to be deployed as aids for us to perform the many actions of fabrication, presupposes that the tool already exists, not that it still has to be made, and it implicitly fosters dependence on what is made available to us as tools, rather than empowering us to make our own and take on a more active role as tool-makers.

Tools impact on what we do and on what we are capable of doing. Following Richard Sennett's account in The Craftsman, *using new tools and old tools in novel ways'* enables us to *gain a new understanding of the natural world* (Sennett 2008, p.195). What he makes manifest is that shaping tools amounts to shaping possibilities, and existing tools embody this explorative development that brought new actions within reach and before invisible things within view. Positioning ourselves inside of these processes of tool-creation holds a promise of going beyond a view of means as something by which something is done, towards a view of means as the manner in which something is done. In other words, it implies a move from the question of 'what' tools to use for a job towards a question of 'how' to devise the adequate set-up, including tools and techniques, for achieving our ends. For that to be possible we have to make a case for their transformative potential and ultimately for making that potential intelligible.

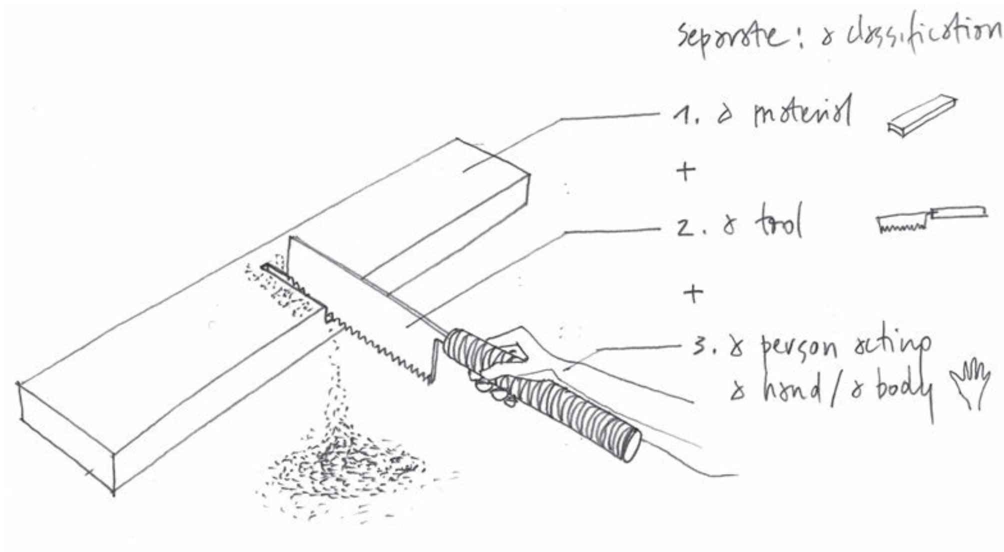
During the workshops we have regularly been confronted with situations in which certain necessary tools were lacking, either because we did not provide them, or because the particular made-to-measure that one needed for the job did not exist. This absence of tools and the awareness of a need arising from the situations embedded in the activities of making things can be picked up and used as an incentive to design and fabricate them.
The primary tools at our disposal are first and foremost our body and hands of course, and it is through and with them that sensorial experience and functional skills join forces. It goes without saying that both hands and body are

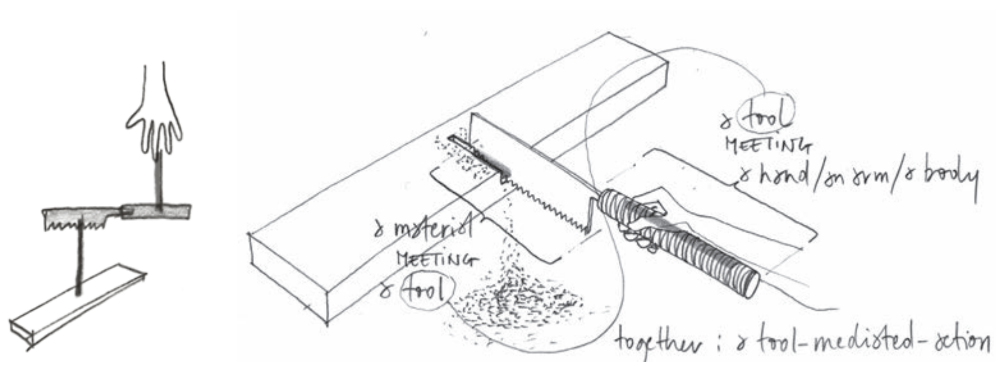
incredibly versatile tools, but they are constrained by our human physical possibilities, as for example with regard to our capacities to experience and cope with strain and pain, or to the intensity of forces we can take on, or to degrees of precision, fatigue, etc. Depending on the conditions, we can experience that our bodily tools may place important limits on, or even be felt as inadequate for doing what we want or need to do.

But our body is just one of the sites of resistance that makes us realize that we need something more than what we have at hand. The point is that we are not the only agents involved in the processes of making. We are engaged in a relational situation with other agents and the influences between them are reciprocal. It is way too anthropocentric to say that it is our hands and body 'as such' that impose limits on the possibilities. It is rather the combinations or confluence of hands/body with (construction) material, designed ends, environment, workplace and co-workers, to name a few, that together set the limits and create a need for additional means.

When the material changes, for example, which happened by default every edition of the workshop, and/or by modifying the rules of the game (the rules of engagement), and/or by revising the desired results (the design), and/or by making combinations of those and other parameters, the necessity for tool-use and tool-making changes. Sometimes these changes can be very subtle but at other times they can become substantial.

Very roughly speaking we can distinguish two groups amongst the several workshops that we did. A first one can be termed as fairly low-tech and hands-on, primarily organized on the basis of a direct exchange between hand/body and the material. This applies to the wicker workshop in Poland (flexibility, pre-tension and a tool for cutting), the brick workshop in Holland (stacking and geometrical pattern combinatorics) and the stone workshop in Ireland (stacking, body power and selection combinatorics). In those three workshops almost no additional (independent) tools were needed, except the logistical tools for having the material delivered to the place of work of course, and the tools needed to run the industrial production processes or the processes for cultivating and harvesting the wicker. But I will leave those out of the picture in order to be able to concentrate on the construction processes within the workshops themselves.


separate : a classification
1. a material
+
2. a tool
+
3. a person acting
a hand / a body


a tool
MEETING
a hand / an arm / a body
a material
MEETING
a tool
together : a tool-mediated-action

For the other workshops, with concrete in Denmark, with wooden plates in Belgium, massive wood in Liechtenstein and steel re-bars in Spain, the picture is different, to say the least. Working with steel reinforcement bars with a diameter of 6 mm and a length of 6 m may not seem that challenging when seen from the distance of this page, but actually it was. When one engages steel rods with the hands and the body as principal tools, one experiences directly what a tough material it is to handle properly. Though being flexible and pliable, it is stiff and hard as well, and the physical effort one has to exert, and thus the amount of energy one has to put in, to change its straight pre-given shape into curves can be substantial. Bending in a controlled way, with dimensional consistency, required the development of tools and a regulated sequence of actions, which became a fascinating creative process in itself.

An Extension or an Intermediary

The situations encountered during the workshops – some due to be developed more in detail hereafter – will prove to challenge the unidirectional manner in which we commonly think of tools as instruments that empower us, or that enable us to exercise or impose our will to form on matter. The maxim stating that *the tool is an extension and specialisation of the hand that alters the hand's natural powers and capacities.* (Pallasmaa 2009, p.48).

duly expresses this attitude. It is the dominant view focussing on the tool as something that is directly determined by and for performing certain specific instrumental actions by us, and as being a specialized and prosthetic device that adds strength, precision, sensitivity, sharpness or whatever other additional functional feature to our hands and body.

> *When in use, a tool is a sort of extension of the hand, almost an attachment to it or a part of the user's own body, and thus is no longer a part of the environment of the user. But when not in use, the tool is simply a detached object of the environment...* (Gibson 1986, p41).

I reckon that this way of framing the issue is recognisable, and when we apply its logic to an everyday and recurrent activity like cutting a piece of wood, we can at first recognize three 'detached' entities, i.e. the person acting, the substance or material 'on' which the action is performed, and the object that is taken in the hand and 'with' which the action is performed, the tool. Each one of them can clearly be distinguished from the others, since identifiably different and seemingly autonomous. Within the activity of sawing itself, the tool is then made to be integral to the body of the person, the volitional subject imposing his will on the material. By a sleight of hand, we go from three entities to only two, being the material and a kind of hybrid, a tooled human body.

Although describing the situation in these terms may appear to make sense, certainly in view of the quotations mentioned above, it is nonetheless wrong, and if not wrong it is seriously defective. At first because it is, again, too anthropocentric, and second because it veils what a tool is supposed to do, namely to mediate between actors engaged in the activity. A tool is actually a 'mediating device' whose position is 'in-between'. It is not of the body, nor is it of the material, it is of both. Once integrated in a process of making, a tool becomes part of the

> *interface between the object (material or artefact or organism) and an environment which, in the case of the artefact, critically includes its maker* (Ingold 2000/2011, p.345).

The saw is in-between the hand/arm and the wood, which is why it is relational. It does not extend the body but rather connects it with the material. The hand holds it, but at a certain moment the wood also holds it and at that moment the action of sawing might bear more resemblance to a tug of war than to a technical operation. During the action of sawing our body is physically connected with the material by means of the tool, and through it the material fabric is made contiguous in such a way that we can feel the substance, its resistance, its strength, affecting us, as much as we affect it with our pushes and pulls that steadily make the incision grow. It is only by being incorporated in this reciprocal exchange, mediated by the tool, that the material can inform us and that we can inform, i.e. shape it or impose a form on it.

A tool, and by extension the apparatus of which it can be part, modifies the conditions in which the work is performed by bringing about a qualitative change in the relationships between a material, ourselves as 'makers', the artefact that is under construction, and the place in which the work is being executed. A tool induces a *transformation in the system of relationships within which the artefact comes into being* (Ingold, 2000/2011, p.345), and our experience, accumulated progressively, workshop after workshop, confirms that this is indeed the case. It also marks a difference between the workshops where the construction activities were primarily unmediated and characterized by direct physical contact between body and material (brick, stone and wicker) and the others in which tool-mediation and tool-technicity were prominent issues (concrete, wood and steel).

It is the combination of both their ‘mediating’ and ‘transformative’ potentials that make tools and apparatus utterly interesting as part of a pedagogy of making ‘architectural’ artefacts at a scale of 1:1, especially when they become design questions that emerge from within the activities of construction in which one is actively engaged.

Reciprocal Determinations

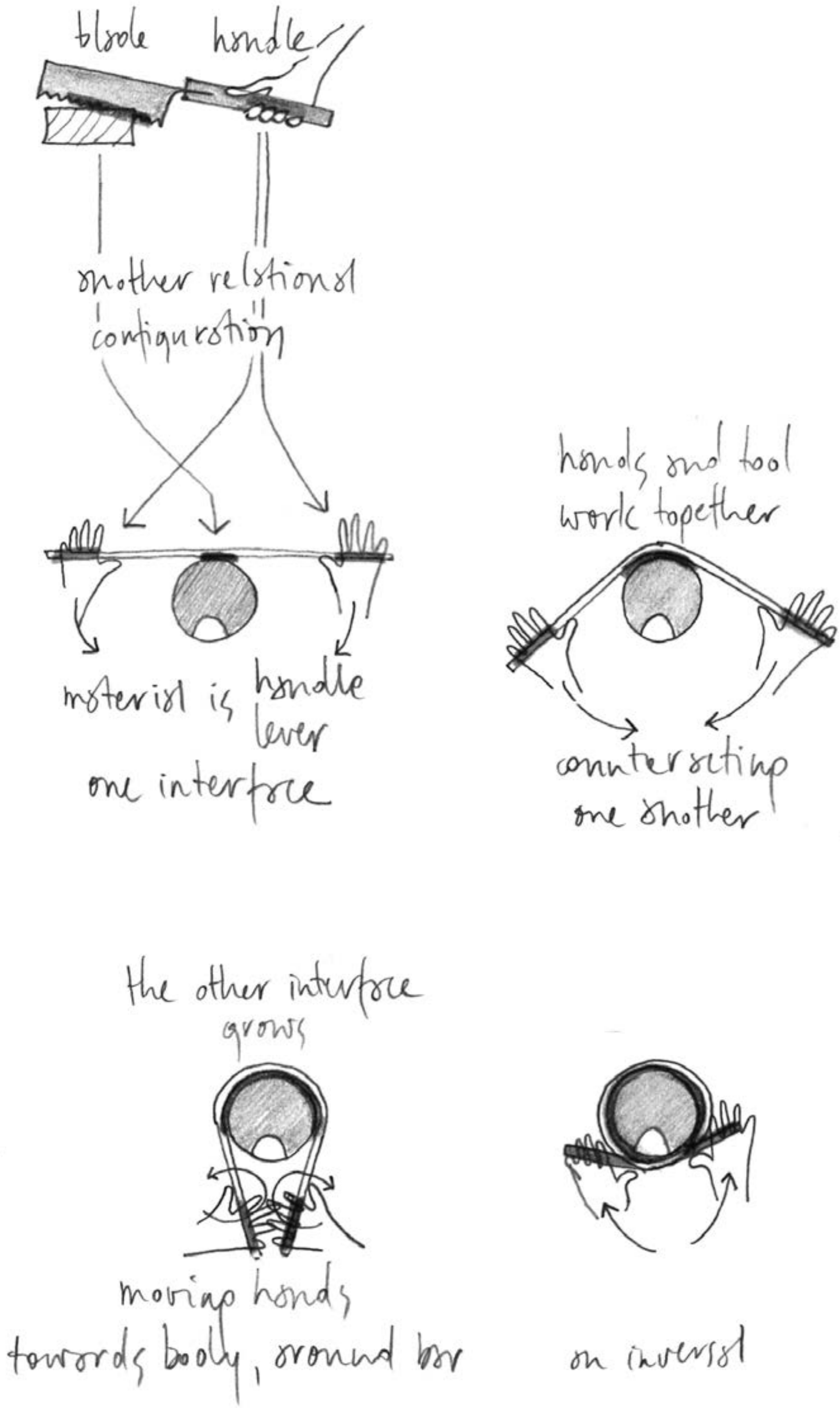
Tools are *equipment for action* and their use is inherently situated *within some worldly situation* (Crawford 2009, p.164). As with their use, their coming into existence is as much determined by the concrete circumstances in which the problems they are supposed to tackle or the situations they are expected to mend arise, i.e. within the performance of acts of making. As such, a tool determines the thing that is made with it and conversely its characteristics are themselves determined by that very thing, simply because it is created from the properties it anticipates upon.

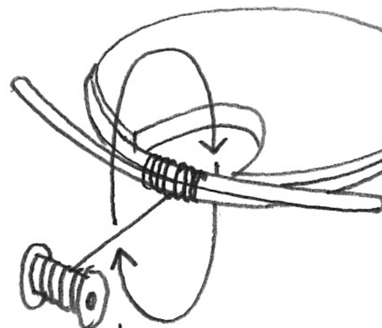
In this context, the practice of making tools must by definition be a design practice too, because the underlying orientation is towards modifying an existing situation that is problematic and needs improvement with regard to the quality of the work, its outcome, its procedures, its actions and/or the conditions within which it is performed. It is a design issue because

> *the aim of designers is to modify human-environment interactions and to transform them into preferred ones. Their stance is prescriptive and diagnostic. … they not only look at what is going on in the world (descriptive stance), they look for what is going wrong in the world (diagnostic stance) in order, hopefully, to improve the situation.* (Findeli 2010, p.293)

In other words, creating tools is projective, i.e. oriented towards a future situation that is different from the existing one.

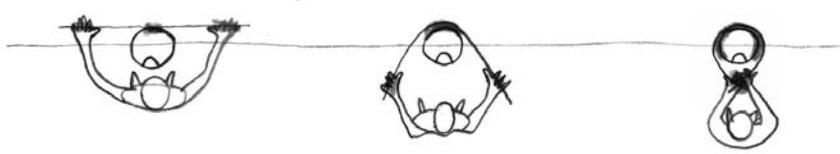
The tools developed during the workshops have to fit into a work process and become integral to it, meaning that they have to participate in achieving a desired result. The production of approximately fifty matching steel rings, about 450 mm in diameter, gave way to demands with respect to both the shaping of circular form and


blade
handle
another relational configuration
material is
handle lever
one interface
hands and tool work together
counteracting one another
the other interface grows
moving hands towards body, around bar
an inversal

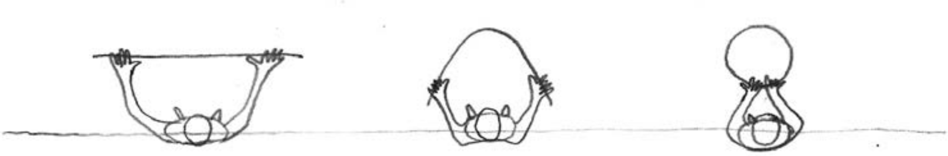


winding tying wire

the body gives way for the hands, gives up its place



for the hands to occupy it and close the embrace



consistency in the fabrication of a repetitive series. At first the rings were shaped by hand, but achieving the desired correspondence between the rings proved to be extremely difficult, and the development of a fit-for-purpose jig was indispensable for ensuring the required geometric and dimensional consistency. But in order for this to be possible the tool had to incorporate a whole set of other specifications: assisting the hands and the body with arresting, retaining, bending, giving form, giving dimension and with making a connection between two ends of a steel rod, hence the notch on one side facing the hands, freeing space for tying.

What is more, the tool needs to possess a capacity to assist/participate in the execution of a sequence of manipulations/operations, just as it needs the capacity to withstand and counteract the forces applied simultaneously by body and steel. All these qualities have to be designed and constructed into it[1], and in this case that would be difficult, not to say impossible, without a feel for what it takes to carry out the job in the tool's absence, accompanied by the intensities of stress and strain experienced while bending the steel freehand and without the repetitive experience of mistakes and failures, whose existence the tool externalizes. It is a material expression of difficulties encountered during the process and that needed a certain kind of attention of their own. The difficulties and the way in which they can be solved by means of *technical processes and procedures, are visibly evident in the form of the tool itself* (Hale, 2014, p.200), they are inscribed in its fabric and structure. And in this sense they can indeed be seen as a *means of capturing and passing on our acquired knowledge* and as a form of *exteriorisation of memory* (ibid. p.200).

1 cf. Flusser, Vilém; The Shape of Things, A Philosophy of Design; Reaktion Books Ltd, 1999. pp.18–19: 'The words design, machine, technology, ars and art are closely related to one another, one term being unthinkable without the others, and they all derive from the same existential view of the world. However, this internal connection has been denied for centuries (at least since the Renaissance). Modern bourgeois culture made a sharp division between the world of the arts and that of technology and machines; hence culture was split into two mutually exclusive branches: one scientific, quantifiable and hard, the other aesthetic, evaluative and soft. Thisunfortunate split started to become irreversible towards the end of the nineteenth century. In the gap, the word design formed a bridge between the two. It could do this since it is an expression of the internal connection between art and technology. Hence…, design more or less indicates the site where art and technology (along with their respective evaluative and scientific ways of thinking) come together as equals, making a new form of culture possible'.

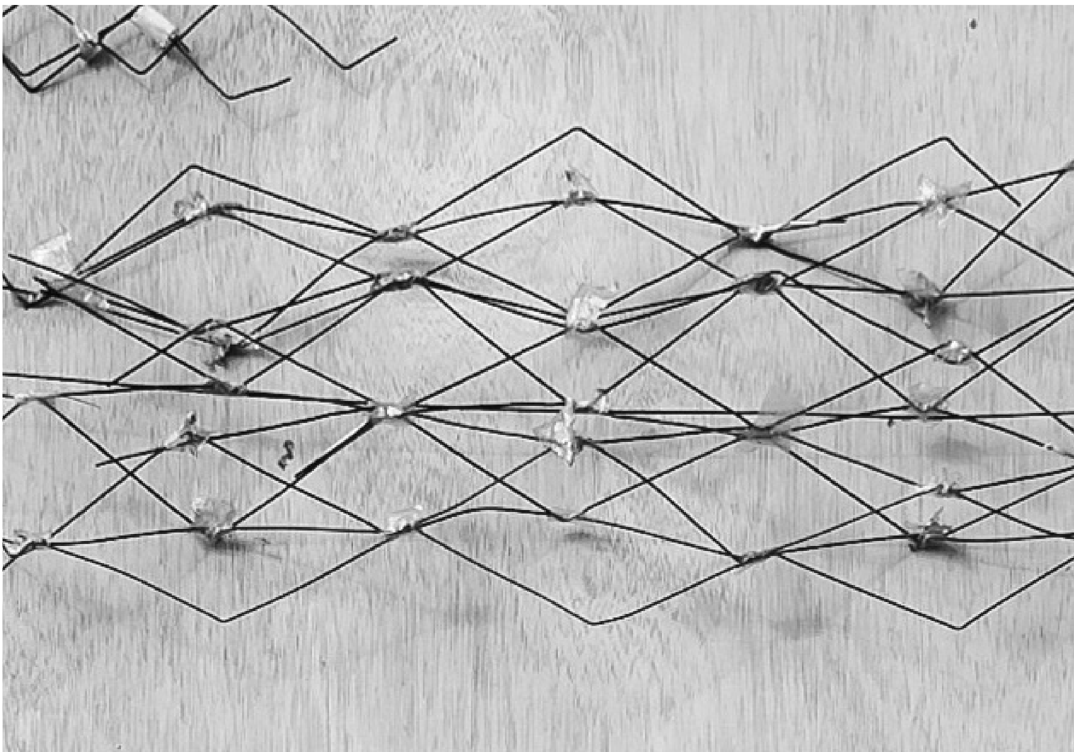
Can the implications of those intricacies be truly understood when we simply see the tool as an object out there, without considering the events that surround it? Using a tool is an event and making one is too. Is tool/technique not a tool-mediated action in which a dialectical relation unfolds between material, tool and body rather than an object?

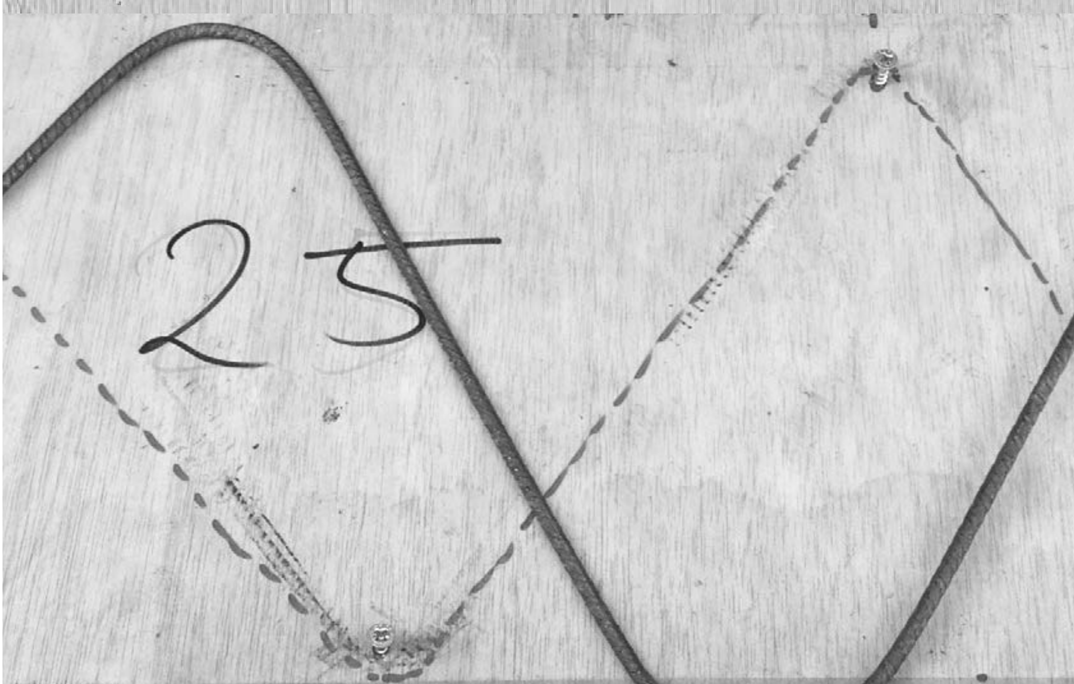
The tool takes a position in-between, in this case even at the centre, with material and body surrounding it. The presence of the tool changes the handling of the steel bar by hands and body in a subtle though significant way. Without it the body can stay put, but when the tool is present in-between, the body has to make place for the hands that are performing a circular movement, surrounding the tool, whilst holding and forming the steel bar in coordination with the tool. It is imperative for the whole body to move, whereas in the other untooled case, it is not really necessary for it to do that because the steel bar can move instead. It demonstrates how a tool influences the way in which a body occupies the space around it during the sequence of formative moves. Those movements had to be repeated over and over to make ring after ring, and eventually they became a rhythm of fabrication.

Controlled Approximations

Making one part, repeatedly or not, does not amount to the whole work, and most of the time parts have to be arranged together to form a comprehensive structure. A construction made with steel lines can clarify why it is necessary to extend the range from the concept of tool as an individual instrument to be taken in the hand, towards the notion of a 'construction of means' or the set-up of a complex of resources, an apparatus.

The intention was that the construction/design process would result in a space frame with a span of 7 m, assembled from steel bars having a diameter in section of 6 mm and a length of 6 m. Although it is normally not part of the workshop procedure, a preliminary scale model, which depicted the wished-for configuration of lines, was made with wire. The existence of such a mock-up at reduced scale always proves to be a tricky issue, because it almost automatically introduces a tension between two conflicting modes or ways of seeing: the model 'for' versus the model 'of', or in other words, it introduced an interesting tension between means and ends. This tension has been running as a continuous thread through the whole process of making. The

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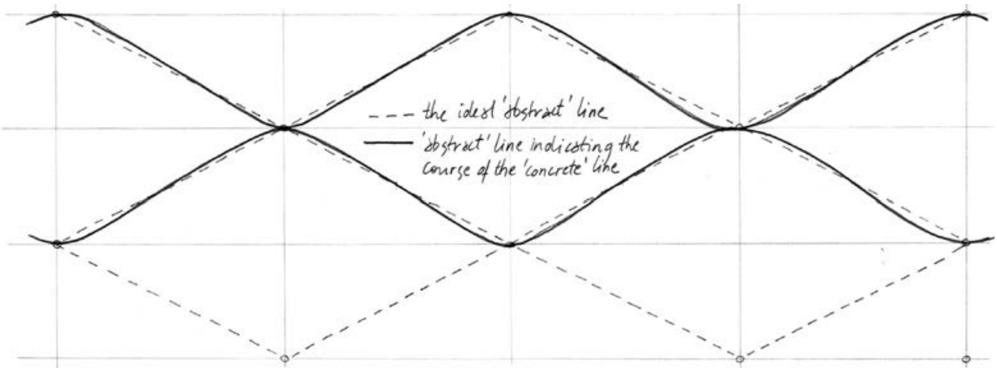
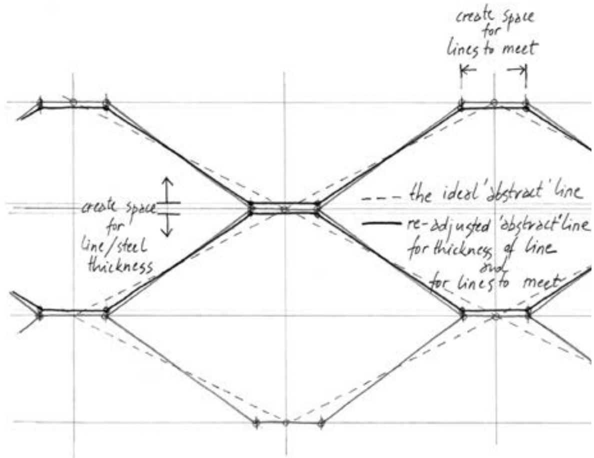
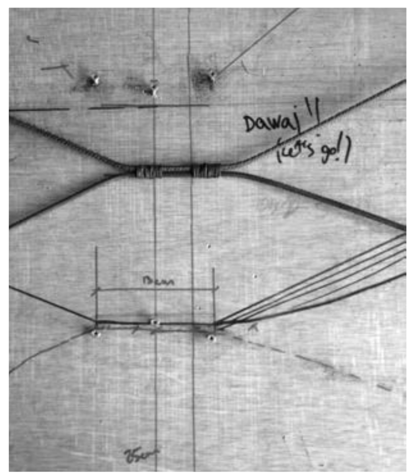
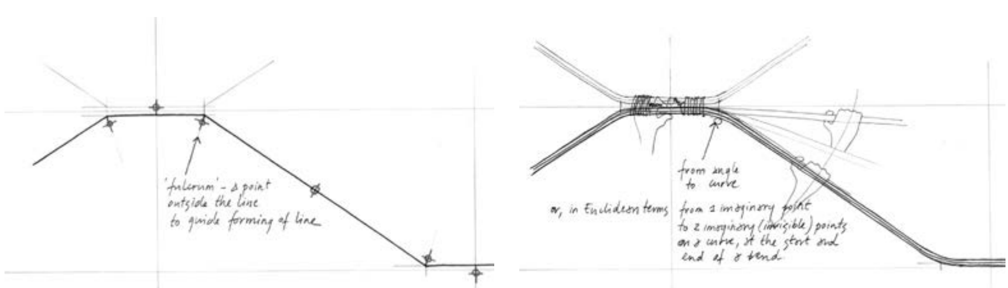


1st approximation





2nd and 3rd approximation



4th approximation

1st approximation
The sharp corners, though drawable, are unmakable with the 6mm thick rebar. The shape has to be re-adjusted and made less sharp, more soft and round.

2nd and 3rd approximation
Lines meet and have to cohere. Space must be provided to unite the lines, to make them hold together. And space must be provided to accomodate for the dimension of the material where lines converge. Two re-adjustments of the geometry are required, again subjecting the initial 'abstract' model to necessary transformations.

4th approximation
'A straight-line is (any) one which lies evenly with points on itself'. Euclid's definition may apply for the drawings, but does it for the steel lines? The (form) of the line is defined by points outside of it's course, lying right next to itself, rather than on it. These points embodied by screws act as jigs that hold and support the line firmly when force is applied to it by the hands in an attempt to modify it from straight to curved.

All corners are curved instead of sharp, and they are all more or less unique due to variations in leverage (as the hand's position always differs), fluctuations in the intensity of the applied force, varying support positions of the jigging screws, opposite bending directions, etc.

'model of' is a representation, an image to be reproduced and the 'model for' is a relational pattern that specifies an 'arrangement'. *The first way of seeing emphasises the apparent in a form, the second way emphasises the form in the appearance.* (Flusser Vilém 1999, p.26)

Giving curvature to a straight line is one of the first issues at hand, and sequences of pulling and pushing, bending and straightening, adjusting and readjusting, organize the formative moves that have to be performed, on and on, to shape and reshape. It amounts to a series of attempts to make a curved steel line conform to a pre-set model, a drawn line. Drawing the line is relatively easy and straightforward, even in a freehand mode, but making the steel line conform to the standard, set by the drawn one, is quite another matter.

To make it simpler, one could drop the demand for conformity and the requirement for increased accuracy that it implies. But since the goal of the activity is to make a space-frame in which lines are assembled with other lines into a fabric of lines, that option is not a plausible one. This knowledge was not pre-given though; it was articulated as a result of making a first piece, which demonstrated that a much higher degree of control and accuracy was needed for both fabrication and assembly. The necessary combination of lines substantially modifies the setting, since it creates a web of constraints. Every single line that composes the structure is not autonomous but situated within a context of other lines. They are components of a system and as such a relational reciprocity, originating from arranging them together, is ineluctable. The fairly simple assumptions that a line has to meet one or more other lines in certain defined places, and the fact that this meeting has to fit, has an impact on how to shape lines, and methods need to be devised that ensure correspondence. It is interesting to see that an increased need for accuracy and control of conformity to a standard seem to emerge naturally from the context of assembling lines together in an 'orderly arrangement'.

Experience with the first piece, which became a kind of unintended prototype, demonstrated quite convincingly that a thorough revision of the methodology of fabrication was imperative if a satisfactory result was to be achieved. All kinds of unanticipated problems arose, problems that are pretty much unimaginable when one is not implicated in the practice of construction, or in other words, *when the conception of work is removed from the scene of its execution* (Crawford 2009, p.208). The *unambiguous experience* *of being wrong* (ibid, p.204) effectively demonstrated the unpredictability that is part and parcel of making things and the risks of failure that are inherent in it. It also proved that the scale model and the process that led to it were inadequate for anticipating what can really be made in practice. As a consequence, it lost its initial meaning as a model 'of' or as the image that was meant to be validated by its reproduction in a built object. This experience of an ideal shattered by physical reality proved to be frustrating and distressing for most students involved in this project, and a few of them took quite some time to get over it.

The failure induced a momentary interruption in the flow of fabrication, and it set a process of gradual reconfiguration in motion, based upon a stochastic process of inquiry, which revealed why things went wrong, and what could be done about it. There were problems of excessive deformation of the space frame (bending and torsion), defective connections, divergent curvatures of component lines, and displaced meetings between them. All these shortcomings appeared at first to be internal to the space frame as a structural system, but they actually were not, or at least not entirely. Seeing the problems as essentially internal to a system isolates that system from the environment in which it comes into being. The reconfiguration of the project, which emerged from the failure, progressively demonstrated to all involved that many of its causes were to be found in the relational set-up between persons-acting, means, expectations, goals, contexts of activity and *activity as dialectically constituted by them* (Lave 1988, p.20). The defective 'prototype' can be seen as a materialized synthesis, incorporating a range of problematic issues that have to be identified and dealt with in due course.

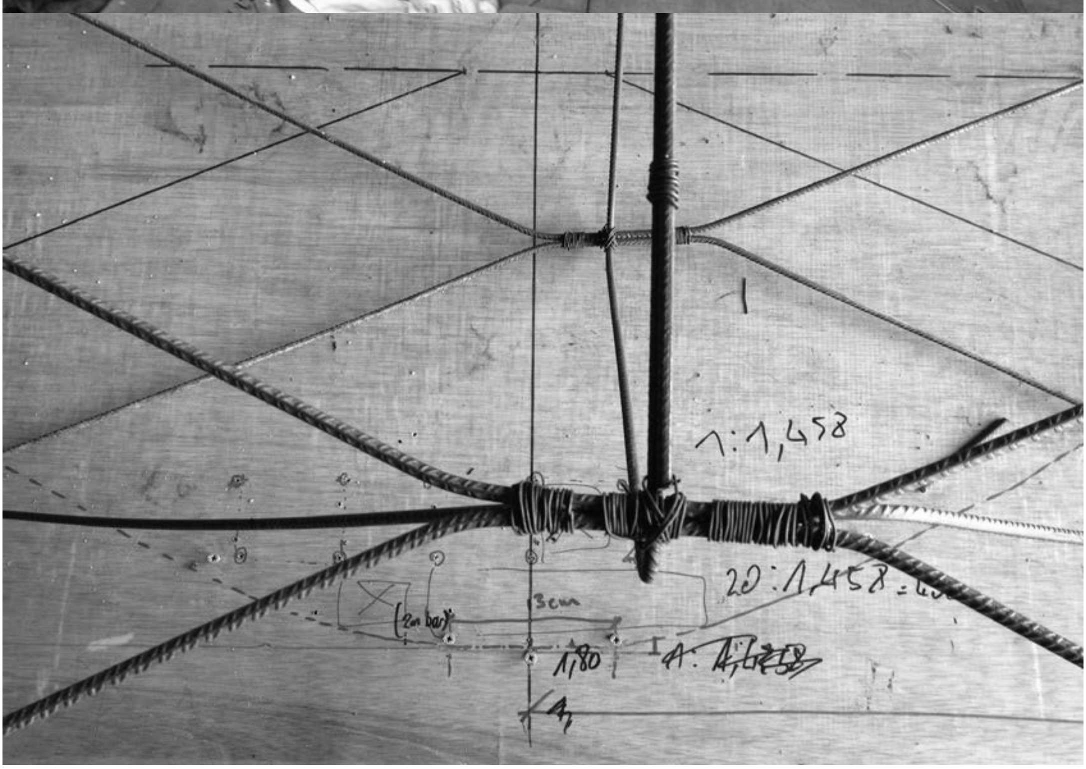
The strategy that was used to cope with the impediments and procedure resulted in something that challenges the classic definition of a tool as an instrument at the scale of the hand. What was produced was an apparatus to fabricate the space-frame at full scale, and it was made tangible in the form of a huge table providing a supporting surface of about 8 × 1.5 m, on top of which the components could be shaped and the entire structure assembled. This spatial configuration engendered a qualitative change in the system of relations between the several actors involved. Eventually it became clear that by its existence the end became possible, but also that the end was transformed through the mediation of the apparatus on several levels:

– That of context through a reorganization of the place where the work is done and by a division between the site of fabrication and the building site
– That of persons acting together, i.e. in relation to each other, through reorganising the workspace. The projects have to be realized in collaboration and devising ways to work together and make things together is of primary importance. Making is a social activity with common ends and within shared conditions. The tool-table-apparatus is a means to organize the work together around it, simultaneously or not, sometimes independently and at other times in coordination.
– The level of procedures: the table allowed for shaping lines and assembling them simultaneously and in parallel
– The level of control of conformity to a standard: on the table top a template was drawn of one line, soon to be complemented by another next to it that meant to visualize both presence of that other line as well as the meeting with it. The template was modified as compared to the initial template and redrawn according to subsequent approximations that gradually improved the line's shape in accordance to the requirements of the whole.
– The level of precision: the addition of fulcrum points allowed for more precise bending; the flat surface allowed for more precision in making the assembly and realising the connections, which in turn made the overall shape more precise.
– The level of persons acting: the surface of work that moved up from ground level (knees in the grass) to table height, increasing comfort for performing the work.

The thing that was constructed for constructing another thing was specialized though versatile, since it had a capacity to be more than one thing: it was a model (template, reference), a surface (to work upon and at), a jig and a place (the table is defined by its surface, but also by the space around it, the one that we use to stand, to work from, to look from or observe, and the place to interact with others and in this sense it had a profound influence on the work as a social activity). It was a mediating device at an architectural scale and level of complexity.

Making Completed in Use

Conceiving and making the material and operational apparatus needed for constructing architectural artefacts is usually not associated with the architect's tasks, but rather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with the tasks of those in charge of the practical execution of the work on a building site. But doing it nonetheless proves to be not only pedagogically relevant, but also intrinsically creative and imaginative.

Obviously, constructing architectural artefacts at full scale allows us to develop embodied experience of materials and material processes through direct physical engagement within a construction practice, and this experience grants us a more comprehensive understanding of the implications that our choices articulated within a design have on both potentials and constraints of that practice. For this reason alone, the value of constructing at the scale of 'real life' is beyond measure, because it implies *the ability to see one's actions 'sedimented' in the solid residues of technical practice* (Hale 2014, p.201).

But there is more to it than this, and this more comes to the fore by means of the position that the apparatus and its assorted tools and techniques take within the processes and actions of making the built work. That built work comes into existence through a complex set of initiating actions that are situated *in front of the work* (Hale, based on Ricoeur, Paul 2014, p.202), where our share, as architects participating in these initiating processes, is situated too. Once the work is completed, our engagement normally ends and we separate ourselves from it and from the recursive processes of use. Our position with regard to the apparatus and its tools is substantially different, and this difference makes up the core of its pedagogical value.

Apparatus and tools, their conception and making, can be seen as an intermediary project, a project nested within another, but with similar demands and characteristics as the project they are supposed to help construct. Means and ends have to be reconfigured, meaning that the apparatus/tool which is supposed to be a means during a certain period will be an end in itself, one that has to be brought into existence first, in order to allow the larger process, that of making the actual or principal end, to proceed. For this to happen, the apparatus/tool must be brought into use and

> *this completes my activity of making them, … gives it social reality. … the maker's activity is situated within a community of use…(that) provides running feedback that can be picked up in the course of … activities*
> (Crawford 2009, pp.186–187).

The apparatus is made 'for use', but is also 'being used', there is a circularity that yields information back and forth between the making for use and the using itself, and this enables us to evaluate achievements, performance and shortcomings in action or practice and sets the scene for improvement. Our relation with regard to the thing conceived and made has changed completely, simply because our position has changed from *the space in front of the work*, defined by initiating actions or actions of making, to *the space behind the work* (Hale, Jonathan, based on Ricoeur, Paul 2014, p.202), marked by recursive processes or processes of use. The development of an apparatus within the larger process of building an architectural object at scale one to one, gives an opportunity to experience both sides, before and after, both creation (projective) and use (feedback) within one and the same process. The point is well captured by the words of Jonathan Hale commenting on a statement by Karl Marx, which

> *highlights two complementary forms of creative experience, which seem to result from the process of making…: firstly the experience of the maker in taking up and transforming a raw material into an object of use; and secondly the experience of the user in taking up an object consciously shaped for human interaction. … The symmetry between the process of constructing and both inhabiting and interpreting architecture.*

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Learning at the scale of “real life” – New pedagogical ideas for teaching architecture

Introduction

Every summer from 2008 to 2014, seven European schools jointly organised a workshop that focused on making. On each occasion we worked with one specific material: brick, stone, concrete, plywood, wicker, steel rods or wooden beams. There was no preconceived design assignment. Instead, the point of departure was constructing with the material itself. The workshops aimed to shed light on the relation between designing and making through an uncommon design process. Instead of the customary process from sketch design to definitive design to construction, during the workshop we built at full scale right from the start. In this paper I will compare this way of working with the teaching methods of artist Josef Albers in the 1930s and architect Buckminster Fuller in the 1950s. Both were strong advocates of the ‘learning by doing’ method and building at full scale. Through this comparison, I want to illustrate and clarify a number of didactic aspects of our workshops.

One-to-one building workshop

The summer workshops took place at venues where participants could work in a concentrated manner so that a shared enthusiasm emerged. For ten days, everybody relied fully on the material and on one another. The participants came from seven European countries, each with its own language and local material. That meant everybody brought their own experience and expertise to the table, which was then shared through material experiments. Communication was conducted largely through the vehicle of the structures made. Participants, students and teachers talked through the material and with their hands.

In the first phase we combined elementary skills with material experiments. Emphasis lay on the material itself. A skill and a design attitude developed. The way of working was driven by the material and by intuition. We experimented in a playful manner without any preconceived ideas or final aim. We searched for the laws the material responds to and the way in which you can use it to build. Every material has its qualities and limitations. We experienced the weight of stone, linked wooden elements together and examined the pliancy of wicker. The findings were not always immediately applicable, but the students learned about the possible applications and limitations of the material. The results became part of the collective memory. What resulted was a body of work, shared understanding, and expertise about the material and a way of working unique to the material.

In the second phase of the workshop we converted the initial experiences into intrinsic knowledge about the material and the method of construction. We used the experience in building a structure on site. Playing and testing were still important motivations, but the focus lay on completing a spatial object on a given site with a structural challenge that stimulated the creativity of the students. We investigated the material in relation to its strength and composition. During the experimenting we abandoned standard rules and habits, thereby encouraging innovative mock-ups of structures and connections. We walked around them, stood back, touched them. The models were built up and adjusted time and again. This cycle led to a focus in the experiments that gradually culminated in a finished structure.

For each workshop we created a context, both mental and spatial. The spatial context was an environment that provided the desired opportunities and limitations. The mental space consisted of the assignment description and the intended work method. The aim of the assignment had to be clearly described and could not give rise to any doubts. In this context, participants could work in a concentrated manner and generated a shared momentum. These circumstances produced a process of slow thinking that enabled students to experiment in an ongoing process of making, reflecting and thinking. Our didactic methods are comparable to the 'learning by doing' teaching method of Josef Albers and the 'one-to-one' experiments of Buckminster Fuller. Their radical approaches led to new ways to develop sensitivity to materials. Both determined the rules of the students' 'playground' in a reverse manner, Albers by restricting the frontier and Fuller by pushing the limits.

Albers' material experiments
From 1923 to 1932, Josef Albers was a tutor at the Bauhaus and then from 1933 to 1949 at the Black Mountain College in North Carolina. Albers was a strong advocate of the principle of learning by doing (*Lernen durch Tun*). According to the artist, simply picking up knowledge and skills hindered real creativity. It is true that education normally offers students insight into design, but no insight whatsoever into the functioning of personal 'creative energy'. Uninhibited experimentation stimulates the student to discover design through the physical process of making, to develop thoughts through looking. Even if the experiment results in an existing idea, it is still acquired in an uninhibited manner. It is rediscovered, so to speak, and extremely valuable for the student's development. Albers acknowledges that education through experimentation is a time-consuming affair:

> *Paths taken lead nowhere and turns are missed. But recognizing mistakes stimulates the progress of the design and the critical attitude of the student. You don't make the same mistake twice. The experimental path develops and stimulates the desire to find the right path.*

In the teaching of Albers, the main aim was activating 'creative energy'. By stimulating creativity, he limited the number of materials and tools. In the projects he set as a tutor, he wanted to give as little theoretical foundation and as few instructions as possible. He let his students work without any restrictions on a material chosen in advance, e.g. paper, steel, wood or matchboxes. By investigating the physical properties of the material, students learned to 'think constructively'. Universal formal principles such as harmony, rhythm, scale, proportion and symmetry were automatically raised when discussing the results.

Making a spatial structure becomes a highly inventive exercise when the only available materials are, for example, paper and glue. Students have to treat the material differently to the way they are accustomed to. They cannot imitate by drawing on tradition. The designer has to search for his 'own' creative solutions. Folded paper structures exploit the strength of folded planes: the corner, the triangle and other three-dimensional structures and patterns. In other words, there are many possible answers to the assignment, each with its own dynamic approach. The material possesses numerous qualities that can be deployed in very many different ways. Step by step, new possibilities are discovered all the time with impartial energy, and that is what Albers wanted to show and teach his students.

Fuller's vision

Using the slogan *More for Less*, architect Buckminster Fuller spent a large part of his career as an architect looking for the lightest possible structures for the biggest possible spaces. With this challenge, he inspired both his architecture practice and education. Fuller was invited all over the world to conduct *Summer Schools*. With the experiences of these events, he broadened his own frames of reference. The results of the workshops were often far from successful: experiments collapsed under their own weight; an exercise with glass fibre and resin failed completely after the elements turned out not to connect with one another after not fully curing. *You succeed only when you stop failing* was the most valuable lesson in this case. You cannot arrive at something new as long as you don't experiment. His experiments fit well in the education programme of Josef Albers, for he too was convinced that you couldn't learn anything new unless you made mistakes. Fuller went a step further by creating a learning environment in which the possibility of failure became part of the assignment. In 1948 Buckminster Fuller joined the teaching staff at Black Mountain College at the invitation of Josef Albers. Fuller introduced into the school his own socially driven fundamental question: how can we build the biggest possible structure with as little material as possible? By making his own geodesic dome project part of the curriculum, he gave students the space to experiment freely, and an environment in which things could go wrong. He demonstrated vulnerability and showed the students that he was searching. The chance that experiments fail is part of the project. The challenge is not to design the form of the dome itself but, rather, to search for structural principles and structures with which to complete the domed structure. Fuller taught students to think systematically about building through structures. He allowed the students to question the underlying structural principles without formal questions. Exploring and reflecting on structure and construction form an intrinsic aspect of designing.

For Fuller, the student projects were an essential aspect of a prolonged process. In the book *How much does the building weigh?* (1990) Martin Pawley writes extensively about the gradual development of Buckminster Fuller's domes and quotes his biographer Lloyd Steven Sieden:

> *Thinking is sorting experiences (...) separating the huge set of experiences that are irrelevant from the very small set of experiences that are relevant.*

Fuller was able to develop his domed structures by constantly experimenting, and that resulted in the discovery of the Geodesic Dome, a self-supporting domed structure made of lightweight materials. One of the many big and much-discussed domed structures was the Montreal Biosphere at the 1967 World Expo.

A plywood construction

The Erasmus Summer Workshop 'Textonical Shapes of Wood' in 2011, organized by the Sint-Lucas School of Architecture, Brussels/Ghent, concentrated on a number of traditional principles in joinery. Wooden components are limited by size. This means that joints always have to be made when wooden elements are extended, widened, crossed or turn a corner. The local carpenter showed us traditional wooden joints with his hands. We practiced making connections with small wooden beams. The students sounded out the material and gained an awareness of its behaviour and the forces acting on joints. A second exercise in 'sounding out' cast light on the art of engineering and experimentation. Plywood has particular properties. The introduction of textile principles such as weaving structures and grid structures generated innovative wooden objects and structures. The students constructed open and airy structures in which every wooden component demonstrates its constructional use and value. 'Playing' enhanced an understanding of the properties of wood, such as flexibility, stiffness, distribution of forces and direction of grain.

After two days of experimenting with the wooden beams and plywood sheets, we relocated the 'field of play' from the workshop to the outdoors, and every group of students chose a building location close to the abbey. The assignment changed from an experiment with material to a site-specific design task. In a short space of time, the students devised a number of structural form concepts in which previously discovered properties of the material expressed something that was already present at each location – a porch in front of a doorway, the nude of a frame in a church, an altar in the church, a hammock between the trees and a lampshade in the abbey tower. All designs called for specific solutions for connecting wooden components. Every part of the object had its own function and meaning. The combination of the right joint and the right technical and structural use of components led to ingenious objects in which structural, engineering and formal aspects came together and in which all components were in a logical place.

One of the most challenging constructions was a giant lampshade of five circles of plywood that were hung in the old abbey tower. The construction measured over five metres in diameter and was made entirely of wood, without connecting elements such as screws or glue. Moreover, the construction was not connected to the tower walls. The creative challenge lay in the confrontation between the weight of the suspended wooden construction and the vulnerable wooden joints. The students formed an interdisciplinary team in which everybody played their own role: one person drew all components, a production team fabricated them, and a third team assembled them into one entity in the tower. The students organised the logistics and coordination of the entire process. They worked in three places at the same time: drawing construction drawings in the studio; fabricating building components in the workshop; and putting together components in the abbey tower. Throughout the process, the tutors acted as consultants.

After some time it became apparent that the carefully drawn and fabricated components did not fit together. The old tower was not perfectly circular and the round wall was irregular. The connecting pieces could not bridge differences in dimensions. Disappointment was followed by the creative desire to solve the imperfection. The students made extra-long holes in the plywood elements and, in a number of cases, additional holes were drilled on site. The construction was less perfect than drawn, but still looked splendid. The rhythms of holes revealed the tension between the perfection of the designer and the manual work of the maker. The 'failure' became a quality for the eye.

The wooden circles of the lampshade were connected to each other with short protrusions like in a deadbolt lock. The extended bolts transferred the forces from one circle to the other. The extended bolt was the lock, but also a beam that made a cantilever possible. The cantilevers achieved stability owing to the increasingly smaller circles that, together with the cantilevered and extended bolts created a sturdy construction in which each successive circle 'pressed itself firmly' against the bigger circle outside it. Every added ring strengthened the construction. The biggest circle pressed the entire construction into position against the wall of the round tower. Every component of the lampshade was essential to bring the entire object into its final shape and hold it in the air. The limitation of the material fed and guided the creativity, wholly in line with Albers and Fuller, resulting in an uncommon construction.

Wicker dome construction

In 2012, together with the University of Gdansk, we organised Wicker Shells, a workshop with wicker as building material. Wicker is traditionally used for weaving baskets. In two days the students mastered the technique of weaving, after a short introduction by a basket maker, and got to work on their own. By slowing increasing the scale of the objects, from basket to architectural space, we challenged their creativity. During the making process, the woven material immediately showed what does and doesn't work. The structure and the construction altered during the process of making. Physical experience with the material helped the students to develop methods to make the jump in scale from basket to built object. Weaving with branches exploited the pliancy of the material, ensuring that forces caused by 'pre-stressing' in the construction were accommodated. The wicker wanted to 'resort', so to speak, to its original position. The elasticity of the material was used to create a strong structure.

In the second phase of the workshop we started to work, just as we did in the plywood workshop, on four carefully chosen locations: a meeting point beside a big tree, a pergola beside the path to the stream, a lean-to roof beside the fire pit and a hideout in the woods.

The work was carried out at each location, which thus became a combination of studio, workshop and building site. The students worked in teams on woven constructions that grew slowly.

The group building a hideout in the woods saw its efforts to make a sphere out of wicker repeatedly result in amorphous, egg-shaped objects. The weight and the unpredictability of the branches caused deviations in the perfectly round shape. The bigger the construction, the more it collapsed under its own weight. The creative challenge lay in the encounter between the 'pliant' wicker and the desired size of the 'geometric' shape. How do you make a fixed shape out of shapeless material? Inspired by Leonardo's Dome, the students devised a construction process in which they set up the sphere from the centre. In contrast to the interdisciplinary team of the plywood roof construction, the group worked as an intuitive collective in which everybody had the same role. Ten hands built the dome construction together. From the centre, the dome construction gradually extended, comparable to knitting a pullover. During the building process the way of working was adapted and improved by everybody together. The main role of the tutors was to provide support, giving an occasional nudge of encouragement to keep the group focused on its intuitive path. The desired geometric form emerged in part by gradually bringing the curved plane into tension in a carefully controlled manner. The right sequence of addition was essential for the final result. The diameter of the sphere was asymmetrical: at the bottom, where the biggest forces act, there were considerably more branches than at the top, where the sphere was even left open. Between the top and the bottom there was a gradual increase in the number of branches used. While visible imperfections emerged during the process of making the wooden roof construction, the process with the wicker dome was almost the opposite. The intuitive, collective process of making led to an ultimate form that was not predicted in advance.

The wicker dome made use of both the pliancy and resilience of the material. During construction the branches adapted the shape. The pliant wicker provided balance and acted as an 'assisting' component. Paradoxically, its lightness and pliancy was essential for the stability and sturdiness of the whole object. Forces were distributed evenly across the whole structure. In the 'dome' the weak materials were deployed extremely cleverly. In addition, they made an important contribution to the character of the built result. And all this acknowledged the advice of Buckminster Fuller: 'Don't fight forces, use them'. The solution was discovered in playful fashion by doing as Albers did: testing and making mistakes.

Diverging and converging

There are striking similarities between our workshops and the material exercises by Albers. Material and actions are deliberately limited: one material and as few tools as possible lead to an unambiguous working process. Moreover, connecting elements, just as with Albers, should be avoided. Students acquired a thorough understanding of the laws governing a material. Limitations were what lent the process depth. In the second phase the summer workshops also added something to the didactics of Albers. For building the objects did not take place in the workshop but outside, in the landscape. The increase in scale meant that the weight of a material became a factor. Because of the scale and limited building time, students had to construct cleverly and think about the efficiency of the building process. They had to work together and organise the building process and building site together. Moreover, the landscape called for an intervention. Unlike an object on the table in a studio, the constructions engaged in a formal relationship with the building site and the landscape. There was a physical relationship. The building site was not a flat surface like the table in the studio, but uneven, sloping or organic in form. Imperfections challenged students to construct in an adaptive manner. The experiments therefore transformed from an object-like scale to an architectural scale in which the efficient and clever use of materials became key.

This is where the teaching and learning of Buckminster Fuller came into the picture. The prospect of a challenging final product (the giant lampshade of plywood or the wicker dome construction) and the necessity of using materials efficiently generated an energetic creativity. Thinking about structures, construction and assemblage was stimulated and driven. Freed from existing conventions, students could discover and deploy their creativity. The game led them along unexpected paths as they made fascinating discoveries and gradually arrived at a fascinating final product. Failures were emphatically part of the process. The structure was not created following the traditional design process that moves from sketch design to definitive design to construction. The spatial construction emerged gradually through a process of making, reflecting and making again.

Both Albers and Fuller stimulate creative energy, Albers by limiting material and equipment, Fuller by setting a structurally challenging goal and offering the opportunity to fail. During our workshops, Albers and Fuller's learning models came together. The limitations of Albers diverged into various creative processes and solutions. Students were stimulated to explore the depth and breadth and explore the possibilities of a material. Fuller then set an ambitious goal that made the discovered possibilities gradually converge in a final product, an exciting spatial construction. Both didactic models stimulated gradual development and slow thinking: Albers by continually encouraging making and reflecting with impartial energy and without any predefined form in mind, resulting in a series of models made of the same material; Fuller by making students aware that these small steps were needed before a big step could eventually be made. A constructional principle gradually developed and reached completion along an unknown path full of failures and successes.

With our summer workshops we are permanently searching for pedagogies that can best ensure the 'design by making' in teaching theory to the architecture students of today. We are looking to integrate the designer and the maker. This is not obvious in today's computer age. In our workshops we re-activate the 'one to one' and 'learning by doing' with new 'rules' to explore the limits from both sides. And to achieve a playful, tactile and fundamental understanding of materials and their relation with construction and space.

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Introduction

Experiencing the materiality of architecture is where it truly begins to exist. This statement concerns the series of intensive workshops within the Structures in Building Culture IP programme. This is confirmed by the words of eminent architect Juhani Pallasmaa:

> *Architecture is essentially an extension of nature into the man-made realm, providing the ground for perception and the horizon of experiencing und understanding the world. It is not an isolated and self-sufficient artefact: it directs our attention and existential experience to wider horizons.* (Pallasmaa 2005).

Peter Zumthor also puts a man at the centre of architectural discourse, and in describing his architectural practice he refers to the humanistic issue:

> *So when I am working, I keep reminding myself that my buildings are bodies and need to be built accordingly: as anatomy and skins, as mass and membrane, as fabric, shell, velvet, silk, and glossy steel. I try to make sure that the materials are attuned to each other, that they radiate; I take a certain amount of oak and different amount of pieta serena and add something to them: three grams of silver of handle that turns of maybe surfaces of gleaming glass, so that every combination of materials yields a unique composition, becomes an original.* (Zumthor 2006).

Zumthor, the virtuoso of timber, stone and glass, confirms how important conscious use of material in architecture is.

He speaks of the precise and sensuous way of using materials, for instance in the works of Joseph Beuys and some of the artists of the Arte Povera group and their artistic approach – anchored in an elemental knowledge of man’s use of materials, and at the same time to expose the very essence of these materials, which is beyond all culturally conveyed meaning. (Zumthor 2006).

In a similar way he uses the material in his architectural works, and believes that only then can they acquire a poetic dimension:

> *The sense that I try to instill into materials is beyond all rules of composition, and their tangibility, smell, and acoustic qualities are merely elements of the language that we are obliged to use. Sense emerges when I succeed in bringing out the specific meaning of certain materials in my buildings, meanings that can only be perceived in just this way in this one building.* (Zumthor 2006).

1
The photograph shows the private house in Jenaz, Switzerland, by archiect Peter Zumthor. In the course of an organized field trip within the framework of the cycle of workshops Structure in Building Culture, the participants' goal was to enrich the topic. In the case of the workshop in Liechtenstein (IP 2014), the main task was to become familiar with the wooden architecture of the region, in particular with contemporary realizations of the protected cultural landscape of Switzerland, Austria and Liechtenstein. Photo by author: Justyna Borucka.

The architecture of Zumthor's buildings fits perfectly into the context of the place [→ Fig. 1]. It is a simple wooden structure with a gabled roof covered with slate. The only modern element seems to be the large glazing without divisions, allowing for an even better integration with the environment and opening the interior to the Alpine landscape.

Material versus landscape

Wood, like wicker, is a particular and unique material, and one of the oldest used by man. Starting from simple huts and primitive shelters, these building materials occupy a central position in the Lower Land Zulawy Region, situated below sea level, and have exerted a significant impact on recent Alpine building culture. Wood and wicker are not unfamiliar to man; they give a tangible emanation of warmth and friendliness and create a sense of protection. These natural materials were always present in the building culture of man.

These materials were easily accessible and formed the basis for the first building structures, such as shelters, giving protection not only as buildings, but in the larger sense, bridging the gulf between architecture and nature, natural landscape.

These materials are naturally present in the landscape of the Zulawy Region but not in the form of a building structure. Wood was easily transported by water. In the wetlands wicker grew in many places, and was a typical landscape element in the area. Similarly, Alpine scenery is rich in trees. That is why the material which belongs to the landscape is always expressed in the material of the traditional building environment. This relation was obvious in the past, and learning and observing the history of this relationship can benefit our architectural practice.

> *Architecture which emancipates us from embrace of the present and allows us to experience the slow, healing flow of time. Buildings and cities are instruments and museums of time. They enable us to see and understand the passing of history, and to participate in time cycles that surpass individual life.* (Pallasmaa 2012).

Careful analysis and observation of the properties of both natural materials, their structure, the quality of individual features, all demonstrate the flow of nature, just as plants pass through successive stages in their development. The Ancient Egyptians recognized that the texture of bark and wood grain reflected natural processes, changing seasons, passing time. Early civilizations recognized the power of

Tectonics in Building Culture II: Textile Blocks, Letterfrack, IRL, 2009

Tectonics in Building Culture III: Concretum, Bornhølm, DK, 2010

Structures in Building Culture I: Textonical Shapes Of Wood, Amay, BE, 2011

Structures in Building Culture II: Skin And Bones, Sztutowo, PL, 2012 natural fibres to form rigid and strong structures. Analysis of these properties allowed the selection of material with qualities suitable for use during the workshops.

Working with materials varies greatly. For instance, wicker appears to be weak but in the process of weaving, bending and connecting it, its intrinsic strength and resistance is revealed. Working with wood is more difficult, requires preparation, strength and knowledge of the craft. From the very vulnerable and easy-to-manipulate wicker requiring mainly manual skills, wood demands complex skills in woodworking, along with the use of machines and advanced professional tools.

The craftsmanship to work with both wood and wicker was developed throughout the centuries. This kind of unique ability to practice with raw materials allows us to discover and understand the building heritage and its importance for the identity of the place.

During the workshops ‘Structures in Building Culture: Skin and Bones’, organized as part of the Erasmus IP in Poland, emphasis was placed on wicker and its interplay with the typical, mainly wooden architecture of the region. The wicker plantations all over the region allowed people to produce goods, but the aim of the workshop was to use it in a different way. There were projects on a smaller scale. However, the models were temporary pavilions which supplemented existing architecture.

The last workshop in the series ‘Structures in Building Culture: Crafting Wood’, organized through the Erasmus IP in Liechtenstein, focused on working with a material that is very different to wicker: solid wood, beams, and planks. The potential of this material, with its significant weight and physical dimensions, was realized in the form of a full-scale model. As a result, real structures were built, which stood in the middle of a unique settlement at an altitude of 1400 metres above sea level, above the valley of the Rhine. Students and professors from several European universities lived and worked in this stunning scenic location, either in Lowerland Zulawy or high up in the mountains, and surrounded by the rural architecture of the Alps. [→ Fig. 2].

2
The village of Tuass, an important cultural context high in the Alps. Photo of workshop material (Meister, U. & Rist, C. (ed.) 2014)

Experiments with the landscape – Wicker

How to use material in a different way that recalls the first primitive structures? What are the traditional methods of crafts? How does one define the contemporary use of wicker structures? How can we transform traditional techniques into modern forms? Such were the initial questions inspired by working on site. [→ Fig. 3].

3
Workshop site in Cyganek, Zulawy Lowerland, Poland. Photo by author: Justyna Borucka.

The context that led to this focus was based on experiences with various materials acquired during a series of international workshops. A model was developed during a workshop, which allowed the observation of working with various materials and creating forms. Each workshop consisted of several days of experimenting with various materials in a specific experimental field. The process of building constituted the core of the workshop. The secrets of matter and shape, and the consciousness of its structure, were discovered by working with the material, in this case wicker, its traditional crafts and experiments with the landscape. Over time it created a whole range of experiences regarding materials and it led us to understand how to experiment with design and be conscious of local building culture and local materials, how to strengthen future projects, and how building culture plays a crucial role in protecting the landscape.

4
The samples were formed at a scale of 1:1 to check details and proportions. Depending on the cross-section of parts used and experimentation with various joining techniques, the combination of the corner became crucial with the final selection of prototypes for implementation. Photo by author: Justyna Borucka.

Experiments in the landscape – Wood

The use of wood broadened the experiences gained during previous workshops. During the wicker workshop we focused on experimenting with the material and the landscape, while building from wood forces a rigid framework implementation. Working with wood is a completely different technique. The project was based on fieldwork at ready-made locations. During the first two days we examined processing techniques and the assembly of wooden elements. Students created prototypes of various connections, patterns, textures, structures, systems of individual beams [→ Fig. 4]. Getting to the material allowed a better understanding of conventional design and construction properties of the natural material that is wood.

However, the process of creating architecture has changed. The creative process also involved exchanging instruments: the drawings for the tools needed for processing the material. Jobs became a real craft. In contrast to previous editions, the implementation of the next phase of workshop drawings requires precise execution.

Realization/Architecture written into the landscape

The framework for the workshop in Poland was smooth, just like the material. The students were free to choose the function of the pavilions located at predefined places in a typical yard in Zulawy in Cyganek. This type of creative work was more comparable to the creation of art. Small pavilions were growing all over the typical timber-arcaded house. Some of the creations flew the traditional arcade entrance, interacting with the existing building and landscape. Creative ideas emerged during the workshop period from the small seating elements in the garden, through the gates from the farm leading to the open landscape, and ending with the primitive shelter – a place of contemplation and rest at the rear of the house. Although all elements were planned in advance, the real creation process started on site. As with art, the ultimate effect was visible after finishing the work, and obviously respected the existing place fully.

The framework for the workshop in Liechtenstein was clearly defined: the village Tuass, an important cultural context located high in the Alps [→ Fig. 2]; the material, which was wood; experienced carpenters and craftsmen, as well as students and teachers from schools of architecture in Europe. The programme of workshops specified the real framework for the project, the location, and the requirement to build four cottages with a square base measuring 5 × 5 m, adapted to modern standards but retaining the heritage landscape. The newly built buildings could not violate existing habitats that are under conservation protection. The simple wooden structures and gabled roofs allowed for excellent integration with the context of the place. A location of individual objects was very specific and required approval from relevant authorities, including environmental conservation authorities. [→ Fig. 5]

5
Workshop IP Liechtenstein 2014 was an additional challenge because it required contact with the customer. Photo by author: Justyna Borucka.

Both of the approaches (freely and completely defined task) ended up with an astonishing effect: respecting building culture written into the landscape.

Meanwhile, in Zulawy yard in Cyganek, wicker elements were adapted to their surroundings, and perfectly complemented the existing landscape and served the residents. They fit into and are firmly rooted in the landscape. Even after several years, their presence still inspires new experiments. At the same time, it does not constitute competition. It is possible to observe the changing colour of the material, the shifting of individual elements, as though they are living their lives. It is now difficult to recognize which element has been added and which is a sign of the presence of people from the past. The perfect symbiosis between old and new material has been achieved. [→ Fig. 6–8]

There are four buildings standing on the Alpine slopes in Tuass. They bounce off the other blackened old buildings


Structures in Building Culture III: Steel Skeleton, Vidrà, E, 2013


Building Tectonic Structures I: Crafting Wood, Tuass, LI, 2014

6–8
Pavilions in the Landscape – IP 2012, Cyganek, Zulawy Lowerland, Poland. Photo by author: Justyna Borucka

of the village at an altitude of 1400 metres. Young architects with experienced carpenters focused on finding new solutions to dealing with old materials. The peace of the village was disturbed by intruders, and for ten days the village could hear the clatter of hammers, saws and engine noises. All materials, cut-pine planks of predetermined dimensions, connectors, and special screws were delivered to site. Previously, foundations for the floor were prepared to the nearest millimetre. Prefabricated wooden floor elements measuring 5 × 5 m were transported by helicopter – very typical in these conditions. Wooden elements, beams and planks were laid in packets on site. Students had to create every hole, every indentation, tongue and groove, by themselves. Carpenters assisted on the site, showing various techniques of processing and combining. [→ Fig. 9–11] When the workshop was finished, the wooden houses in Tuass did not yet have windows or doors. They even lacked a roof, but they created a framework already in the landscape, a framework ready to accept future owners. Each house is different, but each has a traditional log cabin. An essential element of the structure is four walls with small openings. The whole has a simple shape topped with a gable roof. Most of the openings are directed toward the open landscape, and a solid wall to the side of the slope to protect against the penetration of snow in the winter and provide some stability. Despite the contemporary nature of new facilities and solutions applied in each of the houses, one can feel the intimate proximity of the material. The buildings are filled with the scent of wood. It is a space familiar to people because of the relationship with nature and the landscape, but also because of the sense of nature and warmth offered by the wood. The material of the houses is still living and still changes its parameters. Slowly, it adapts to the environment and landscape by its colour, dimensions and structure. It will collaborate with the man who created it.

Conclusion
The days of building with wicker and wood were divided into two stages. The first allowed us to become familiar with the material. It was a process in which a variety of skills, knowledge, experience and culture complemented our craft. This process was interrupted with questions. How to interpret the typical building in a modern way? How should I make a structure? How to connect material in order to achieve a required effect? The second stage

was the implementation of the selected solutions. Initial experiments in contrast to the implementation phase were not preceded by drawings and ideas, but were born during model building at scale 1:1. The basis for the implementation of solutions and transformations were traditional craft techniques and inspiration from the landscape where everything was happening.

It was the direct contact with the material: the touch, the smell of freshly cut beams, the specific sense of what gives wicker its properties – it all gave us the basis and opportunity to look at the material in a creative way. The workshop was an experience that made it possible to gather relevant knowledge and skills. It was also the sensual experience of communing with the material and place, which cannot be achieved in another way. The result of working in the Zulawy Lower Land in Poland and Alpine village of Tuass in Liechtenstein, in addition to the construction of four wooden huts, also provided protection and space for human activities. It demonstrated the effects of experience while working with natural materials. And now, how Zumthor says:

> *We must constantly ask ourselves what a use of a particular material could mean in a specific architectural context. Good answers to these questions can throw new light on both the way in which the material is generally used and its own inherent sensuous qualities. If we succeed in this, materials in architecture can be made to shine and vibrate.* (Zumthor 2006).

This enhances the architectural practice and likely contributes to the creation of conscious architecture. That's the goal that should be inspired to by an architect and student of architecture.

9–11
Construction of houses in Tuass – IP 2014, Alps, Liechtenstein. Photo by author: Justyna Borucka.

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Tectonics in Building Culture III: Concretum, Bornhølm, DK, 2010

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Structures in Building Culture II: Skin And Bones, Sztutowo, PL, 2012

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Building Tectonic Structures I: Crafting Wood, Tuass, LI, 2014

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