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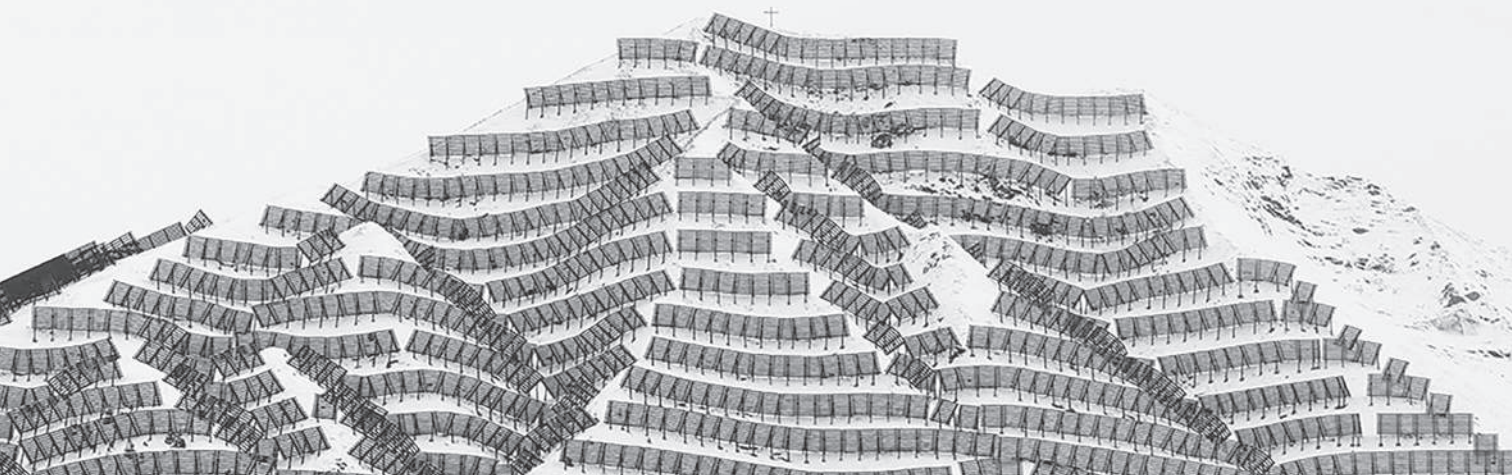

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3. ESPERIENZE CONTEMPORANEE

Application-oriented digital tools for timber construction. Dialogue with Yves Weinand

Edited by Roberto Dini and Cristian Dallere

Over the past two centuries, steel and reinforced concrete have played a predominant role in research and application in civil engineering and materials science, leaving a void in structural wood research. However, the environmental arguments in favour of expanding the possibilities of using renewable wood resources are becoming increasingly evident. in recent years, society's growing awareness on the urgent need for sustainable building materials has influenced the newfound economic importance of timber construction. Environmental awareness is helping to restore or establish the legitimate use of wood in building our cities on an unprecedented scale. This essay is an interview with Prof. Yves Weinand, in which he briefly explains the experimental activities taking place within the laboratory and how these are changing the way we design and build with timber. On a broader level, the investigations of the IBOIS Group contribute to a deeper understanding of spatial structures in general and set new precedents for the cooperative interaction between architects and engineers who will be analysing such structures.

Yves Weinand

Architect and civil engineer, he is one of the most recognised researchers in the contemporary wood construction. His fundamental research questions the technical and static possibilities of wooden materials. The interdisciplinary exploration carried out at the EPFL's Laboratory for Timber Constructions (IBOIS), of which he is director, concerns wood in all its aspects, from round wood to manufactured wood. Through new innovative approaches, the ambition of his research is to develop a new generation of renewable and ecological wooden construction.

Keywords

Timber construction, digital architecture, interdisciplinary approaches, technology transfer, innovation.

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Yves Weinand's approach regards the mechanical requirements of form and structure as attributes that can gain full meaning and sense only in the context of the geometrically scaled phenomenon on which they depend. He considers the use of the digital representation of architecture as an invaluable tool that ought to strengthen the integration of structure, form, and material within our design concept. However, digital modeling cannot replace the study of physical reality, which is crucial when designing form and space and, integral to them, structure. He directs an interdisciplinary group of architects, engineers, mathematicians, and computer scientists, who perform research work in the fields of timber rib shells, folded timber plate structures, woven timber structures, integral mechanical wood–wood connections, and robotically assembled timber structures.

How can you briefly describe the activities of the IBOIS research centre? How important is the multi-disciplinary aspect in pursuing experimentation and innovation in this field?

At IBOIS the relationship between engineering and architectural design are explored. IBOIS is part of the Civil Engineering Institute ENAC/EPFL, but it is also affiliated with the Department of Architecture, where an architecture studio is made available to engineering master's students. Thus, collaboration between architects and engineers is encouraged, providing the environment for a wider scientific community within architecture schools Europe-wide. The research at IBOIS focus on construction and the challenges of realizing complex shapes and free forms. What is the relationship between basic research and applied research? What is the connection between pure research and applied research? Or between curiosity-driven research and problem-oriented research? And finally: how can the scientific research in architecture be reconciled with the artistic dimension of research, in order to bring them into harmony with one another?

IBOIS provides a place to innovate, where the fascinating inductive-experimental approach is combined with the clarity of deductive-scientific methods. This is undertaken with the aim of creating new forms and types of structures – particularly timber structures.

In addition to its sustainable qualities, timber also has exceptional mechanical properties, which can be utilized in specific structural forms.

For centuries, timber construction has been governed by the use of linear elements connected to truss systems. However, in contrast to steel and reinforced concrete – the dominant building materials of the nineteenth and twentieth centuries – engineers have done little to develop the use of timber as a building material. Now, thanks to the availability of digital tools, applications of this material can be expanded significantly; new geometries can be created; and innovative construction materials and methods can be developed. In short, we can undertake an innovative exploration

Opening picture
Detail of timber Pavilion of the Théâtre Vidy-Lausanne (CH) (photo Ilka Kramer).

Fig. 1
Prototype of a double timber folded plate structure assembled with snap-fit joints. Christopher Robeller, Yves Weinand, IBOIS 2014.

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Fig. 2
Timber Pavilion of the Théâtre Vidy-Lausanne (CH), 2017. Architect: Yves Weinand Architectes sàrl, Lausanne, locally assisted by Atelier Cube SA Lausanne (CH). Timber Engineering: Bureau d'Études Weinand, Liège (BE). Technological transfer: Laboratory for Timber Constructions IBOIS, EPFL (photo Ilka Kramer).

Fig. 3
Chapel of St.-Loup, Pompaples (CH), 2008. Architect: Yves Weinand, Hani Buri, Localarchitecture + EPFL IBOIS. Timber Engineering: Bureau d'Études Weinand, Liège (BE). Technological transfer: Laboratory for Timber Constructions IBOIS, EPFL (photo Fred Hatt).

of structural engineering with regard to timber. Here, the current ability to use structural planes plays a vital role – for example, large-scale multi-layered boards, plywood, or laminated veneer lumber panels.

What is the philosophy of the IBOIS research centre regarding the utilisation of wood resources in mountain areas?

Due to a lack of digital tools, the Swiss timber industry in mountain areas largely exports mostly unprocessed lumber and imports finished timber products. By using new digital design-to-production workflows, it has become possible to investigate new building systems for small scale structures using local timber for local applications.

While automation in raw wood fabrication is a well-studied field there is a lack of integration

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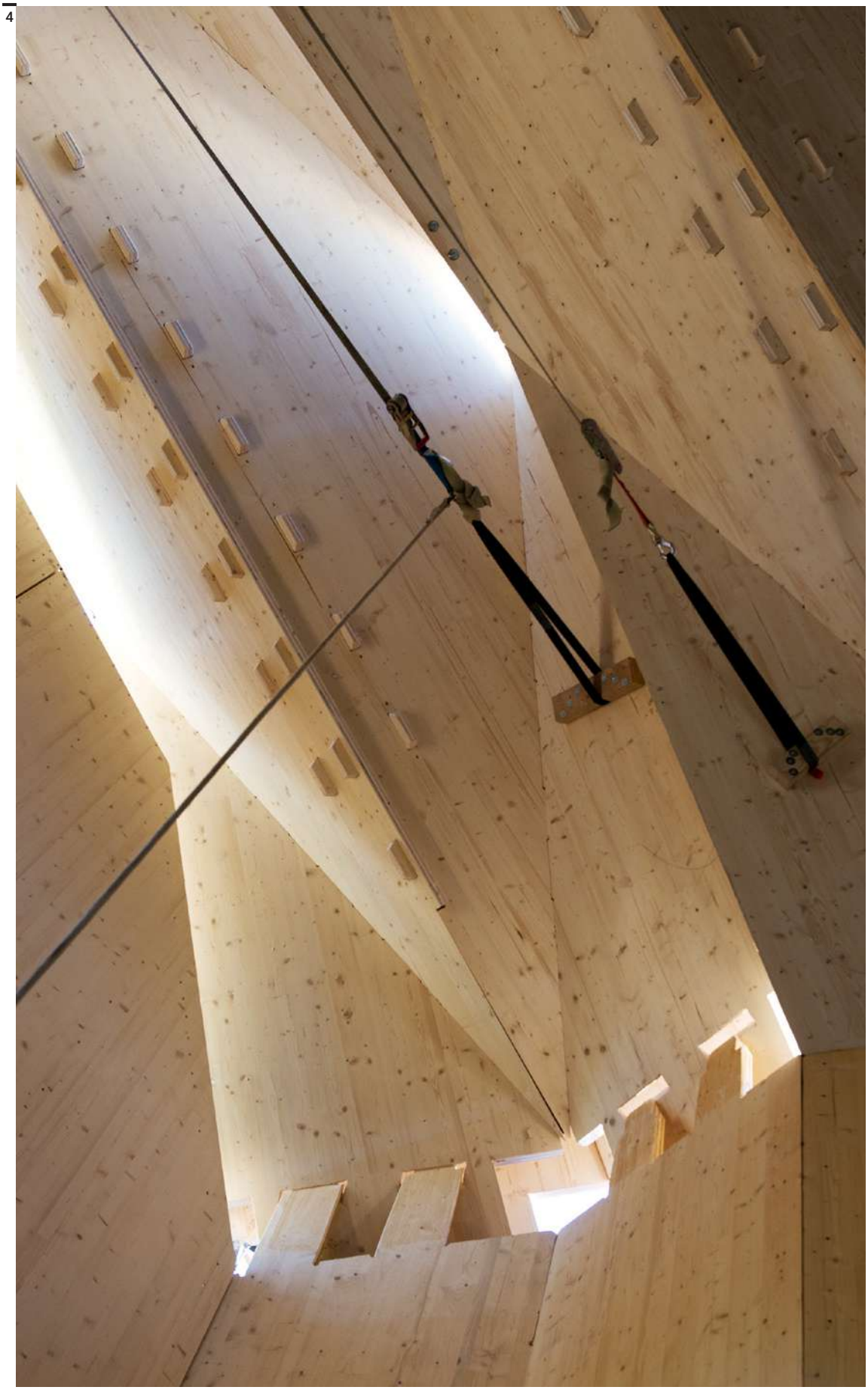

Fig. 4
Assembly, timber pavilion, Théâtre Vidy-Lausanne (CH), (photo Ilka Kramer).

Fig. 5
Point cloud describing the irregular geometry of a tree trunk (Petras Vestartas, 2021).

into the local timber industry. One of the innovations that could be transferred is the use of round wood. This is one of the most advanced and promising fields of experimentation that we have to offer: rethinking the use of unformatted wood, that is to say round wood, as a potential component of a construction. The purpose here is to avoid standardisation, along with the cumbersome logistics and waste it generates, so we proceed by scanning the trees in order to deduce the shape of possible construction components. This reconfigures not only the wood processing cycle, but also its requirements in terms of energy, time and spatial resources. Not to mention the savings in biomass this generates, since by working in this way we will optimise the resource far beyond anything imaginable today. The idea is to create a library of building parts, from which builders can select the ones they need. By adjusting the act of wood processing to the forestry activity, we would create an unprecedented optimisation mechanism, both for the forestry side and for the builders who would be able to design according to the resources, available to them. More generally, what can be passed on is the whole technique of automated shaping, which structurally associates the shape of the resource with that of the ready-to-use construction component. This way of building, based on available wood, existed in vernacular architecture: the aim is therefore to revive it in the twenty-first century, using the tools and technological means at our disposal. This principle is associated with the development of parametric models, associated with installation and maintenance systems. Automation would make it possible to reduce the cost of installation-which remains high today, given the scarcity of specialised craftsmen. The advantage of this approach also lies in its experimental nature: calibrating the size of the elements in relation to local tree species.

The experience of Jean-Pierre Neff, mayor of Rossinière and carpenter, underlines that, in the mountains, wood was a very local resource as it was often used in the immediate vicinity of where it had been logged. The carpenter oversaw not only the drying, but also the settling of the wood. He had this profound knowledge of the material, which he was required to master. Today, all this no longer exists, but could be revived through technological applications capable of making this local construction circuit viable again. We are not going to ask people to go back in time and work with manual tools. But

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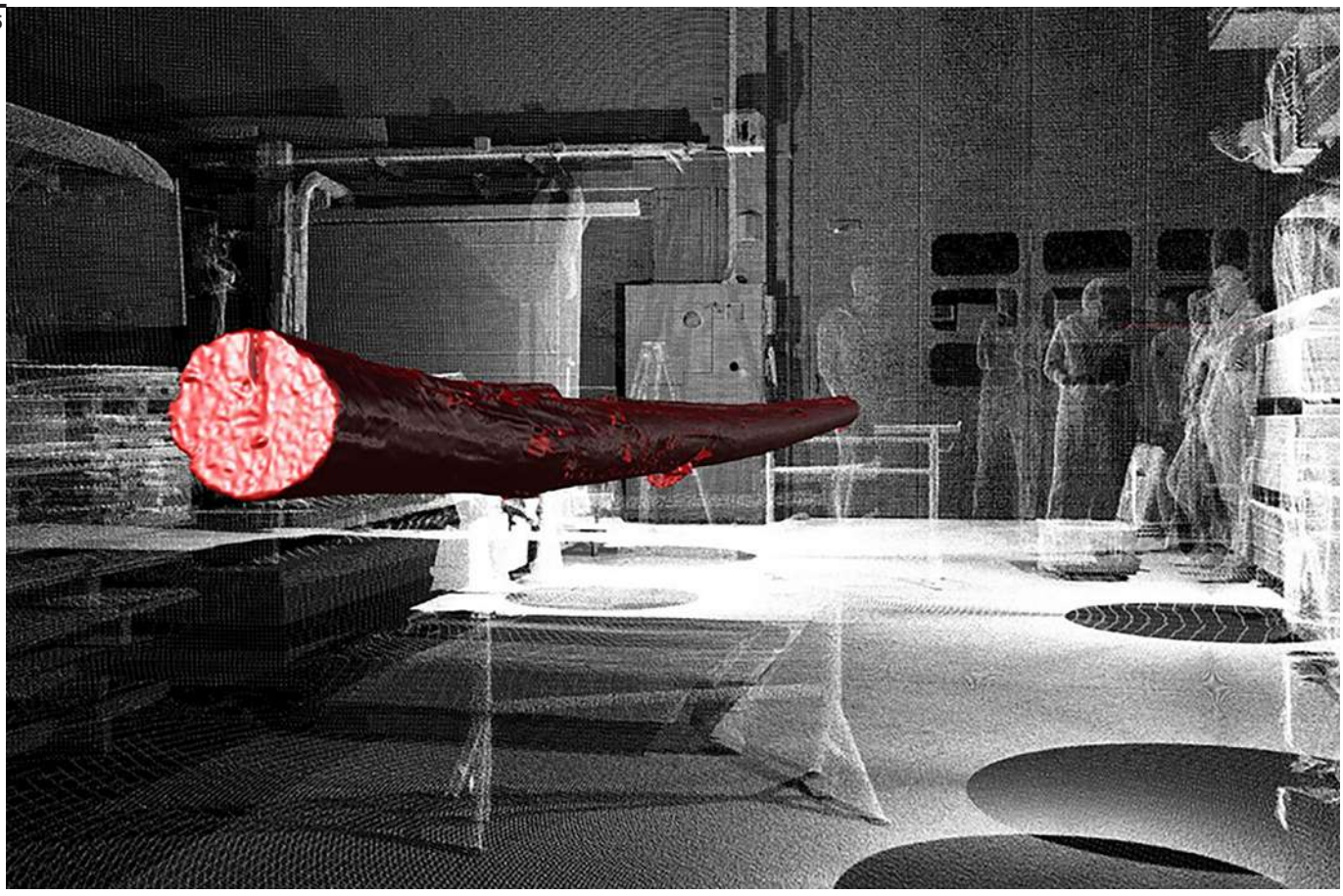

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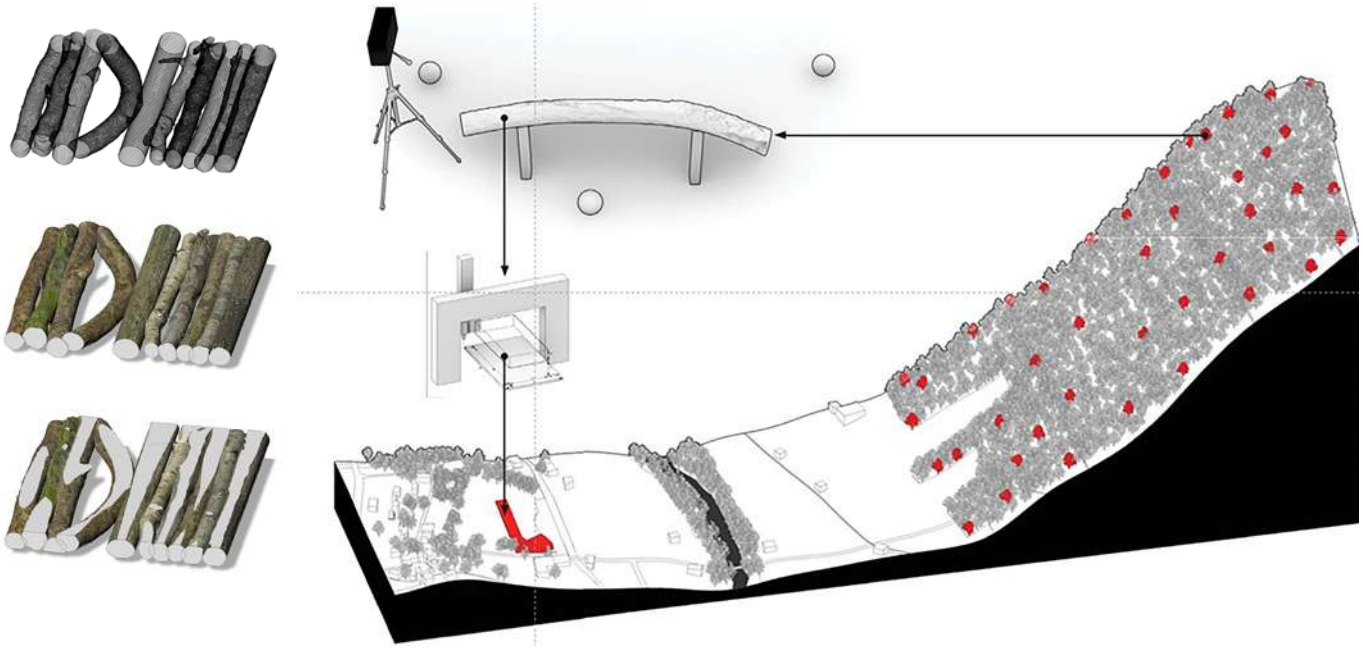

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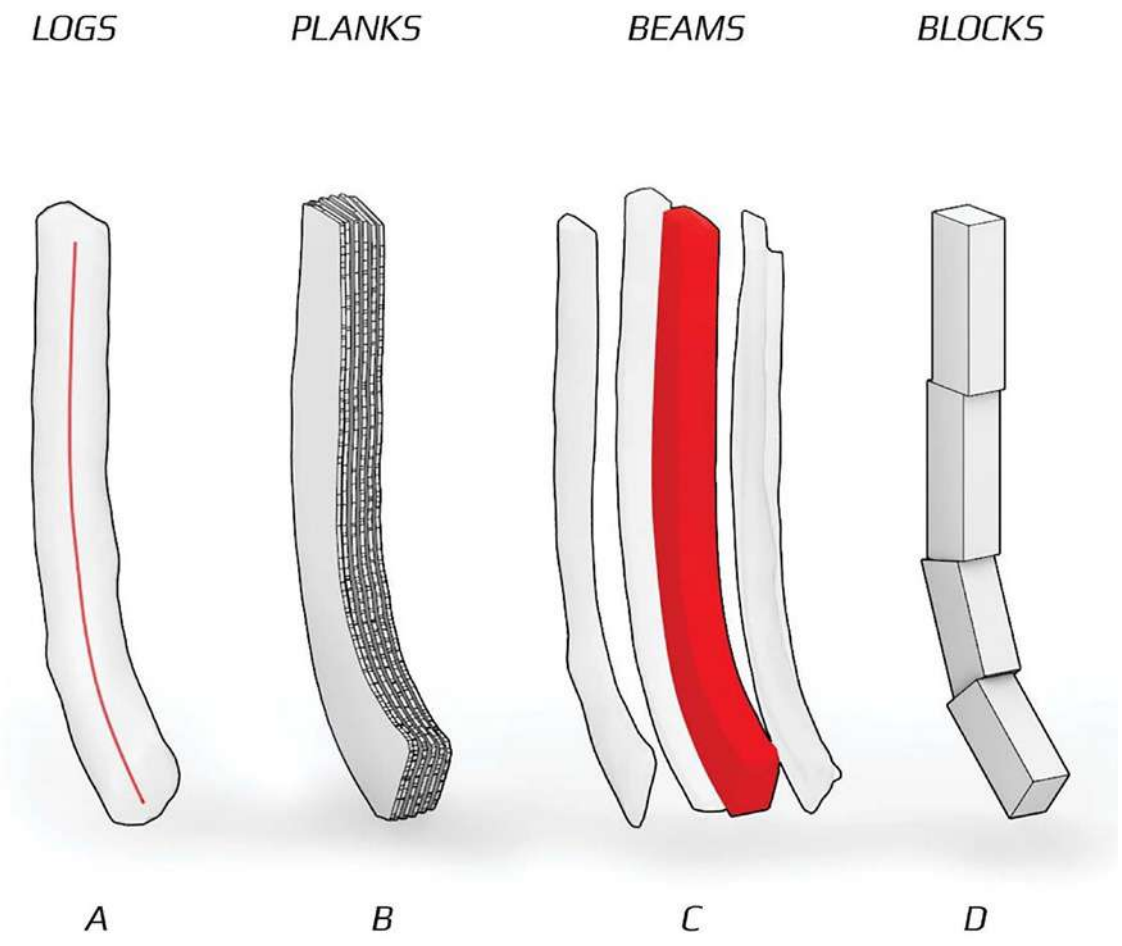

Fig. 6
Rossinière, centre d'activités gare grand chalet. The process of scanning the trees in order to deduce the shape of possible construction components (IBOIS).

Fig. 7
New possible sawn mill formatting procedure (IBOIS).

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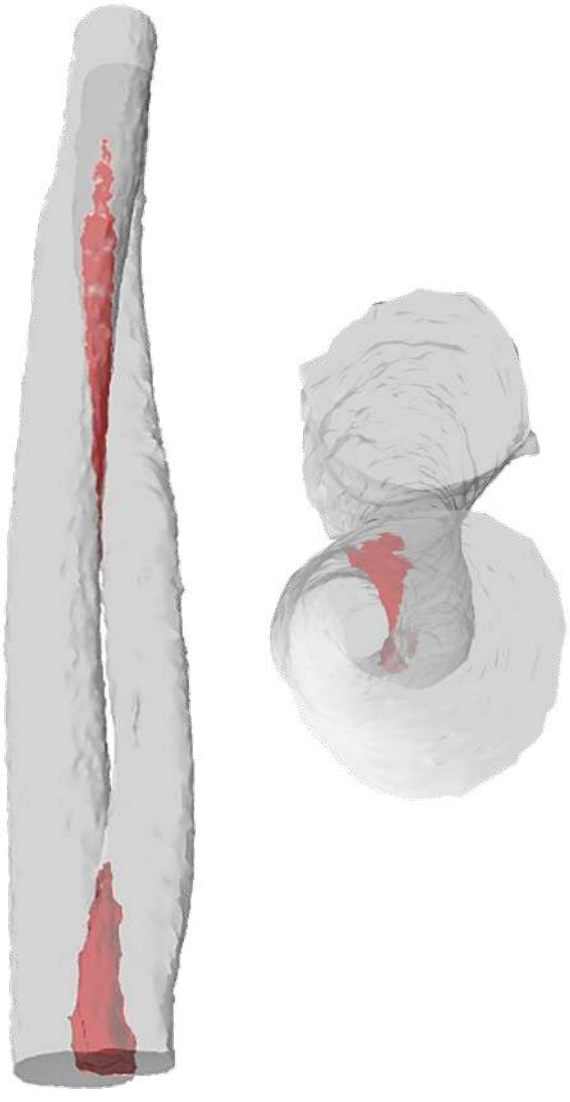

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Fig. 8
Robotically shaped wood-wood connections (photo IBOIS).

Fig. 9
Individually shaped round wood trunks forming a column (IBOIS).

Fig. 10
Newly developed side/side and top/top wood-wood connection (photo IBOIS).

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thanks to digital tools, we can regain the intimate knowledge of the material that craftsmen used to have. The aim is to reduce the number of steps in wood processing to a minimum, and to use solid wood as much as possible. This is exactly what the wood scanning project could do. It is a wonderful opportunity to re-establish an attitude that was the rule for a long time: choosing the tree in the forest according to the intended construction. Today, in protection forests, trees are not chosen for felling according to production criteria, but according to the maintenance of the vegetation and the tree's protective role.

From a process point of view, how is the relationship between the use of forest resources and architecture changing? How are new digital design technologies responding positively to environmental and sustainability requirements?
With the onset of climate change, the concept of sustainability has finally become a central issue for our twenty-first-century society. In this context, our research focuses on the following question: by ex-

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Fig. 11
Truss connections taken advantage of naturally grown timber nods (photo IBOIS).

Fig. 12
Wood-wood connection taken shear forces within a double column (photo IBOIS).

Fig. 13
Hexagon massive timber trunks forming a continuous shell structure by means of lateral wood-wood connections (photo IBOIS).

panding the applications of wood as a construction material, could its use in the construction of public buildings be boosted?

Regardless of its typology or function, a building always consists of a myriad of small elements. Wood and wood-based materials are made up of the assembly of smaller parts. Solid wood, timber beams, plywood, laminated timber, and laminated veneer timber panels are all produced from the amalgamation of smaller-scale parts. For this reason, the technology of the junction connections should also be considered in the synthesis of these materials in a building. The variety of existing timber materials and the considerable versatility in their application should determine the manufacturing and prefabrication methods.

The aim of the research is to find solutions to a number of questions. We are interested in discovering new construction solutions that can be easily incorporated into hardware stores' offerings, to enable the affordable realization of unconventional architecture. One of the most important ways to reduce construction costs is to use a digital design tool. The development of specific, application-oriented digital tools would thus appear to be imperative. Our tools will help at the interface of architecture/civil engineering, mechanical/geometric design, and form-finding/parametric digital prefabrication, in specific, project-related steps.

How do you think the process of innovation and experimentation can change the way of conceiving the morphology of an architecture made entirely of timber structure?

Good buildings that are immediately convincing and in which one feels at ease, that surprise and astound us, have one thing in common – a successful synthesis of technology and spatial design. The art of deploying construction technology in such a way that it forms an integral component of the design and actively helps to shape it is what Kenneth Frampton defines as tectonics. Tectonics is rooted in timber building because the Greek word *tecton* signifies 'carpenter', or 'builder' in general. The art of the carpenter thus hallmarks all of architecture.

In an interesting dialogue with Antoine Picon, professor at the Harvard Graduate School of Design, it emerged that there has been a crisis of tectonic thinking in the field of architecture, except in the

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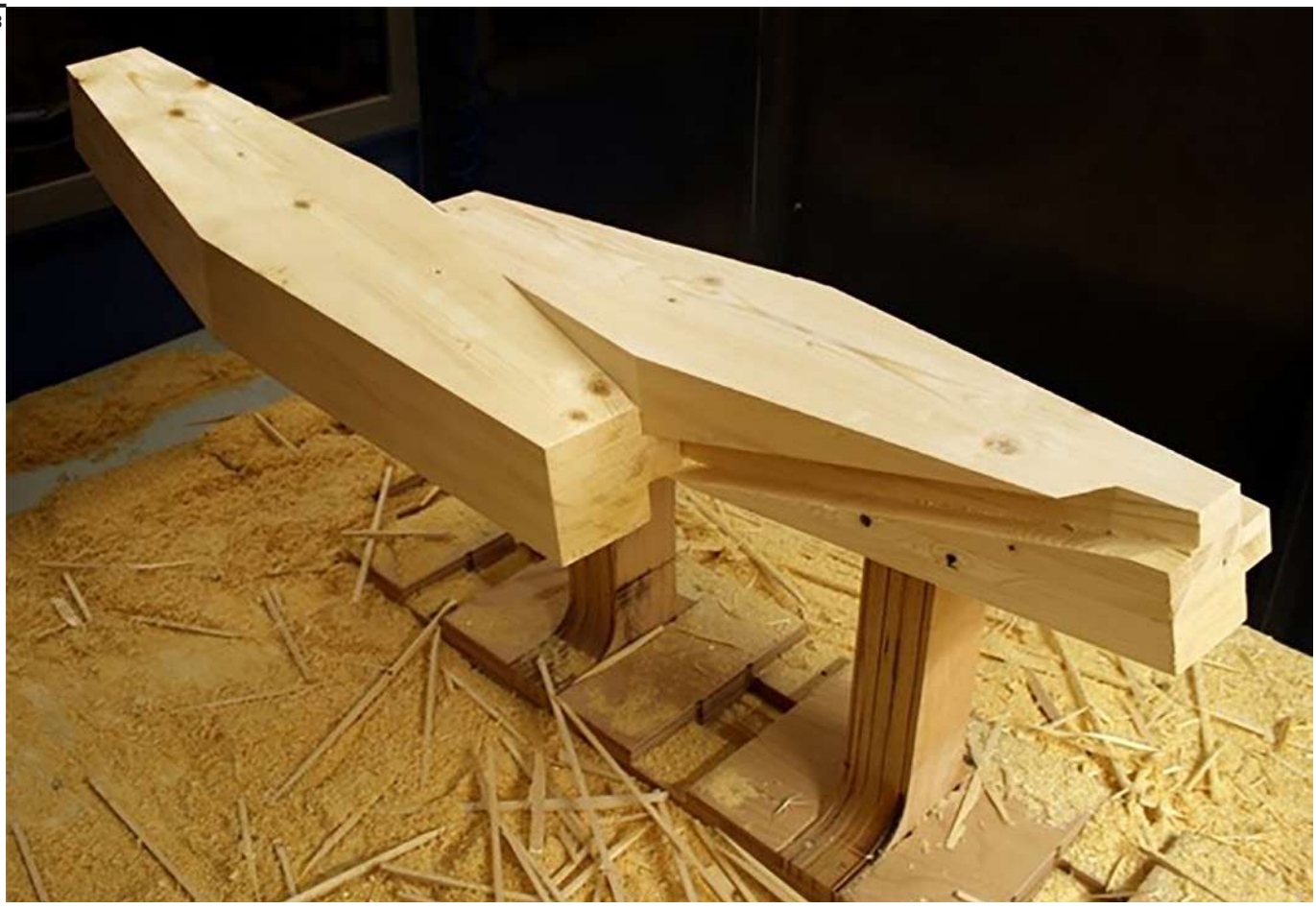

case of timber construction, as this is a material that can hardly be separated from tectonic thinking. There is a real gap between the pre-eminence of the tectonic approach in timber construction and its under-representation in theoretical thinking in architecture. Curiously, the advent of digital technology initially led to a certain decline in traditional constructive themes. These neglected themes are now coming back, closely intertwined with ecological and climatic issues. We are now realising that questions of assembly, dismantling and material production are also central.

When considering the usefulness of theory for a practice like yours, you have to start by saying that in the field of architecture, theory covers two different activities: one consists of justifying a practice, seeking to elucidate the principles and values that it adheres to. The other is to ask disciplinary questions of a critical nature and to challenge the attachment of a discipline to its foundations. In this respect, the question of know-how in architecture is a theoretical question. There has been a resurgence of interest for the physical aspect of things. And this necessarily marks a return to the artisanal aspect, to the question of making.

In terms of tectonics, from the perspective of designing timber structures, it is essential to talk about assemblies. In this regard, engineers can now dispense with the classic stability plans grouping together families of details of a certain type and distribute connections and bearing points of different kinds over the whole structure in order to better distribute the internal forces and avoid concentrations of stresses. This is interesting, compared to the classical engineering plan and the engineer's way of approaching the question of the structure. The assemblies studied at IBOIS are contemporary in their use and their ability to be dismantled and reused. When one speaks of materials in terms of grey energy, wood is again exemplary. Taking these two aspects into account legitimises this new imperative to no longer simply consider the costs of building a structure, but also the cost of recycling its materials. In the case of concrete, the subject is too rarely mentioned.

Timber construction demands interdisciplinary approaches, involving architecture, civil engineering, and material science. A new generation of timber derived structures is also an act of creativity within the field of architecture and specif-

Fig. 14
Connections allow a 2D or 3D shape to be discretized into simple parts specific to a particular material fabrication technique (IBOIS).

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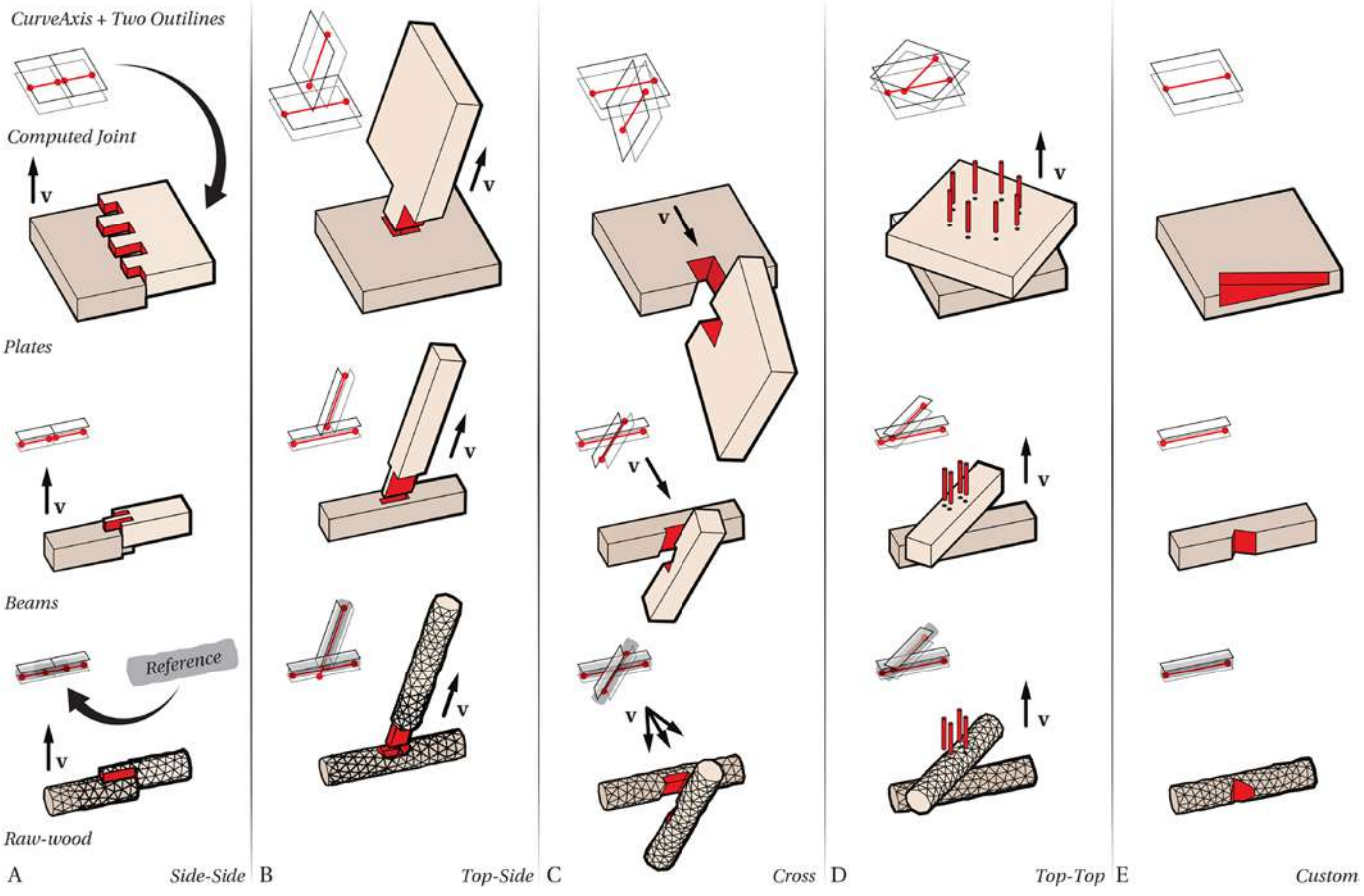

ic contemporary architectural approaches. The raw resource in question has innate qualities (such as smoothness) that can also satisfy aesthetic and conceptual qualities that architects value. The emerging tools in digital architecture and design software seen as an instrument to conceive architecture have opened the way for broader applications of digital technology, including those of a technical nature. The old-fashioned image of the 'chalet' and related vernacular architecture will be replaced by a contemporary interpretation; our research helps establish timber as a modern, high-tech material that can play a central role in a society concerned with sustainability. In this way, it is essential to talk about tectonics. Three main factors determine a building's tectonics: the material, the tools, that is to say, the technical possibilities for working with the material, and the design. The use of computers has led to sweeping changes chiefly in the processing of the material and in the design process. At the same time, timber as a material is also continually being developed further, opening up new technical and design possibilities.

How do you think the timber construction market will move in the next years? What possibilities revolve around the material?

Timber construction has a promising future especially in relation to climate change and our need to find sustainable solutions for the construction industry and to implement the use of appropriate building materials. Timber's comparatively low energy consumption has been a known fact for years. Challenges around sustainability in the construction industry also touch on the question of architectural form. At the Department of Timber Structures, IBOIS, EPFL Lausanne, we posed the question of how a formal and technologically innovative process might be developed from a sustainable perspective. The renewal of construction technologies and technical procedures in timber, taking into account the innate qualities of the material, could lead to the increased use of timber in contemporary construction. This is not about the principle of longevity or permanence, on which modernity is based, "modern" implying that which lasts, or that which remains. Timber is generally regarded as being a traditional building material. This preconceived image is advantageous to socially legitimate research that is about finding complex shapes, or creating freeform structures, when it is done in timber.

Today, public and private clients alike demand novel solutions in terms of both sustainable, high-quality architectural design and construction methods. Architects and planners ought to meet this demand by initiating and guiding innovative processes like the ones studied at IBOIS. Furthermore, solutions for so-called "non-standardized" architectural forms that are sustainable and economic should be found. ■

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