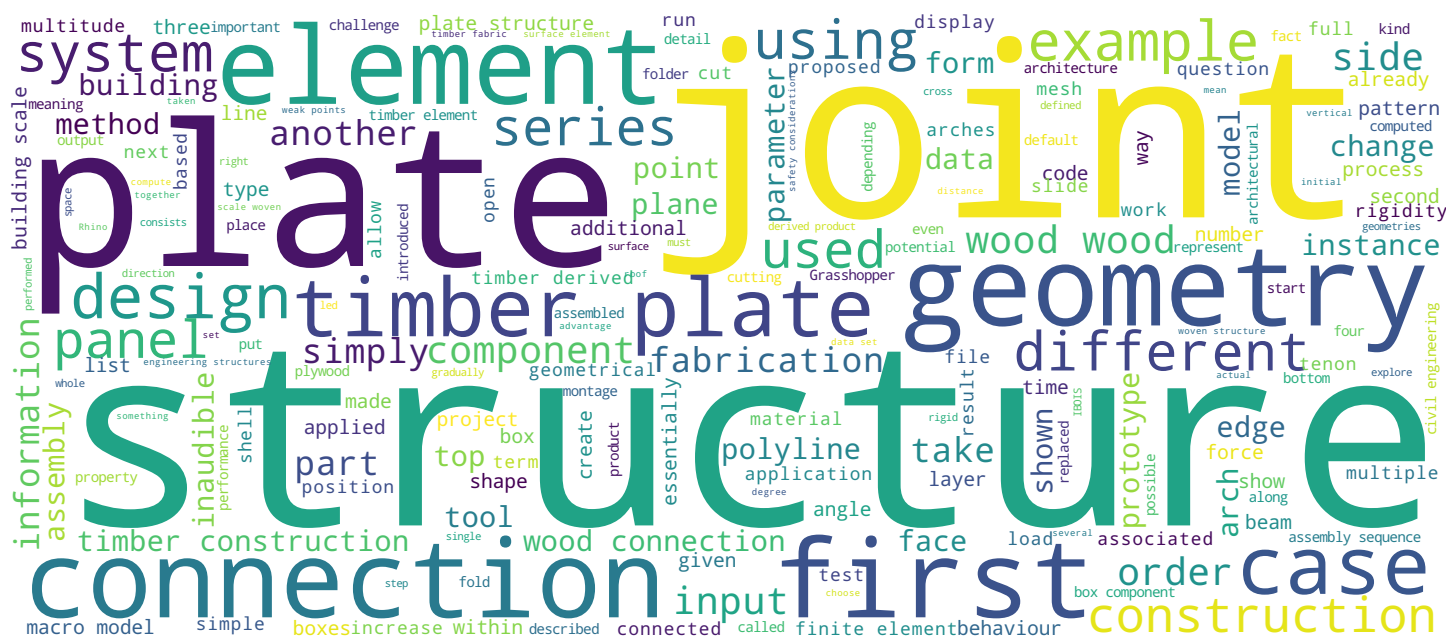




EPFL
IBOIS

IBOIS research

Prof. Dr. Yves Weinand



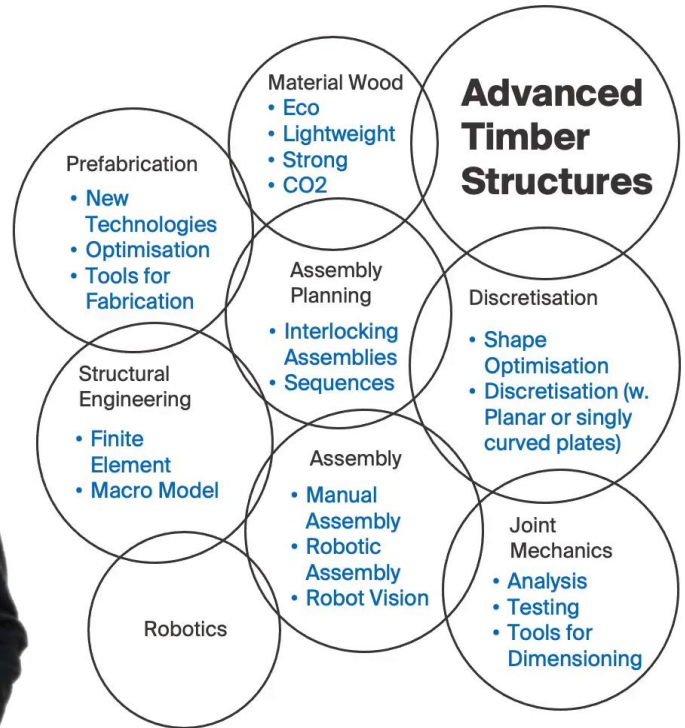
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EPFL

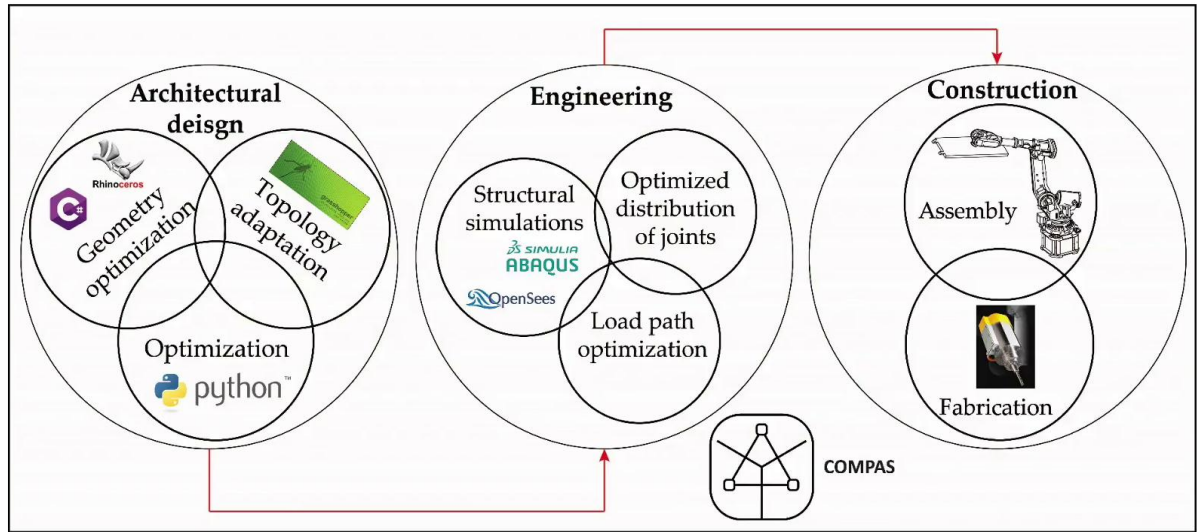


Our research aims both to explore and to challenge the traditional relationship between engineering science and architectural conception. It is ultimately concerned with the question of construction in real space as perceived and used by society. Therefore, we, as researchers, took right from the beginning, a quite different and unique point of view devoting our attention to exploring in-depth how materialization and physical aspects of real structures are related to the representations in the digital world.

Notes

Summary



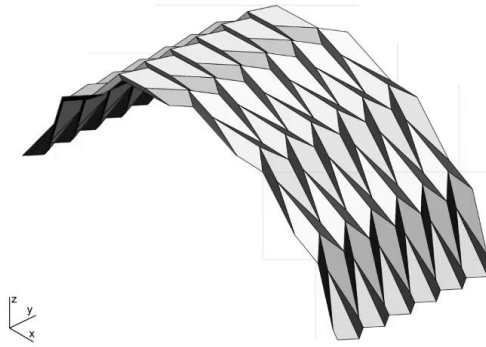
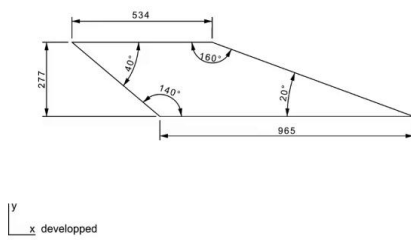
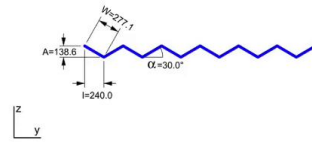
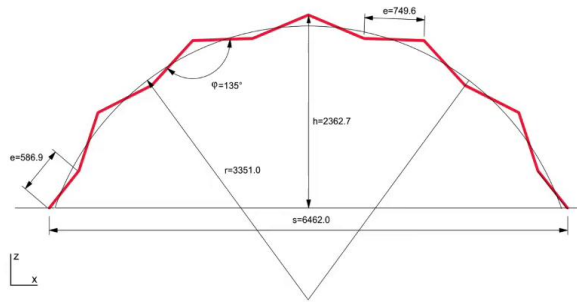


We seek to accomplish construction solution which could be successfully disseminated throughout a construction market meaning that the realization of unconventional structures at a reasonable cost must be an obligate goal.

Notes

Summary



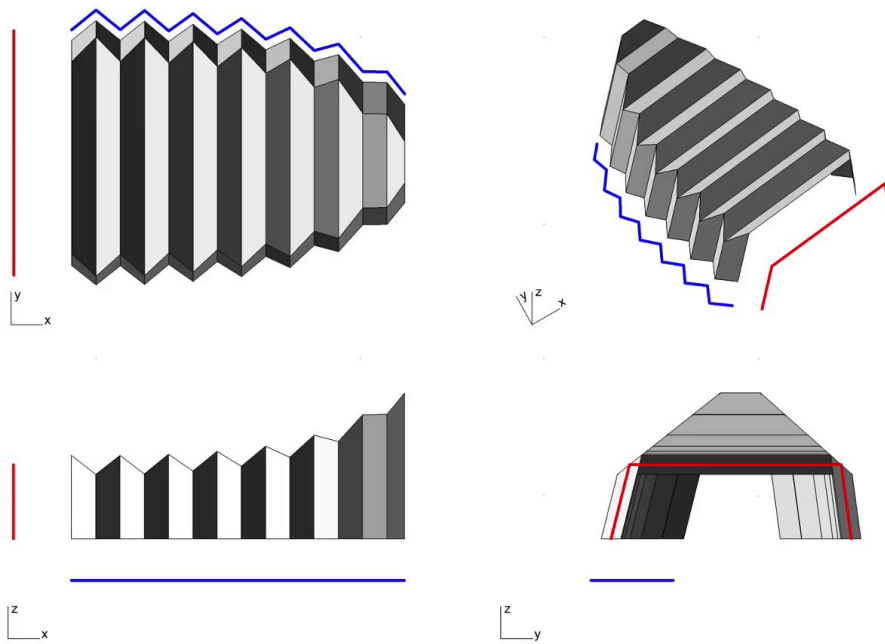


Origin. It is inspired by the vision of building as an integrated planning process, where craft, technique, aesthetic, and structural engineering aspects, converge as they did just before the revolution and age of enlightenment, but this time using contemporary engineering methods and tools.

Notes

Summary





This demonstrates an act of creativity within the field of architecture and specific contemporary architectural approaches. The raw resource in question has innate qualities that can also satisfy the aesthetic and conceptual qualities architects are interested in.

Notes

Summary





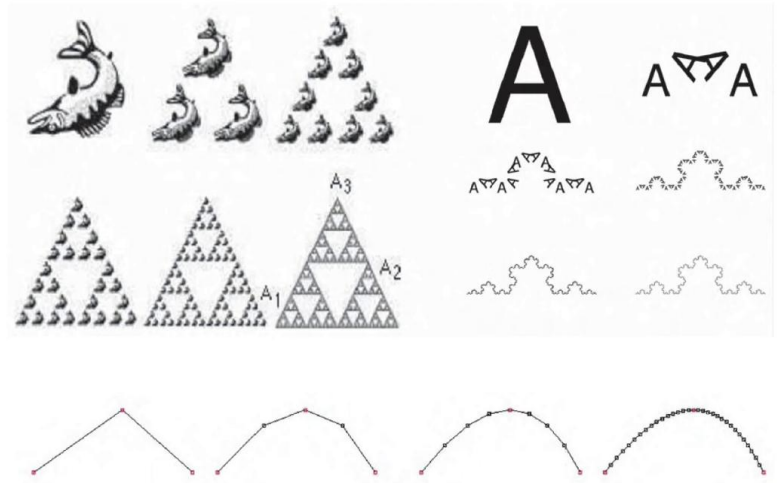
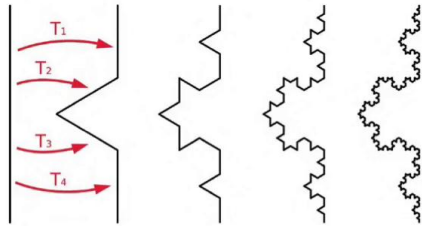
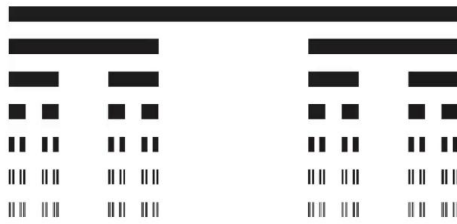
Iterative function system. This radically new generation of timber structures can change the face of timber construction as an architectural form, both lifting it out of the classical image of traditional architecture and expanding the use of timber in construction of contemporary character. The old fashioned image of the Chalet and related vernacular architecture will be replaced by a contemporary interpretation of timber use in our construction. It should establish timber as a modern, high-tech material playing a central role in a society concerned with sustainability. Within this context, interest in employing timber as a construction material has increasingly revived. Innovative timber derived of products such as laminated veneer lumber boards produced with the readily available type of woods have emerged, and the use of such products is spreading. The anatomy of timber as a natural fiber-structured composite should be able to reach higher structural performance when local weak points can no longer affect global stability. This consideration has led in the past to the innovation of plywood.

Notes

Summary



1m 36s

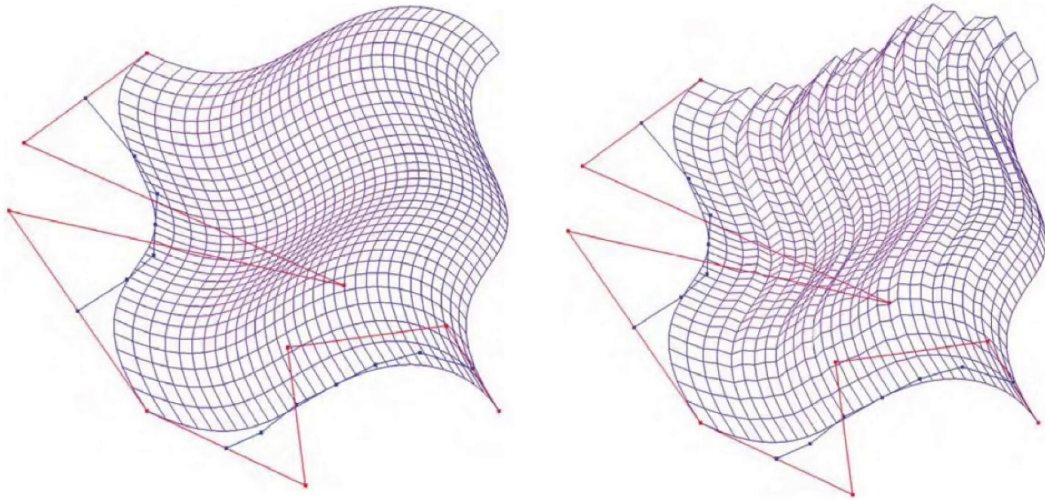


Since plywood is made out of several layers of timber sheets, the sum of those layers is stronger and more rigid or subject to less local failure than the same amount of material taken out of one naturally-grown piece of wood. In plywood, local knots, random exists plays a less critical role, since they are covered with stronger layers. Taking advantage of this same principle on another scale, we intend to compensate such randomly appearing weak points contained in a given timber fabric by a multitude of adjacent and slightly more resistant members, who will sustain each other like a fabric using their woven quality and choose not more working independently. This will raise the parameter characterization value, we call global failure ratio. Here, spatial timber-plate construction, especially the way they are deployed, provides exciting perspectives. They offer high resolution networks composed of many individual components. Furthermore, they provide the advantage that singular element failure does not trigger the entire system failure. Such structures that meet large deformation without rupture, a property that is highly unconventional for civil engineering structures.

Notes

Summary



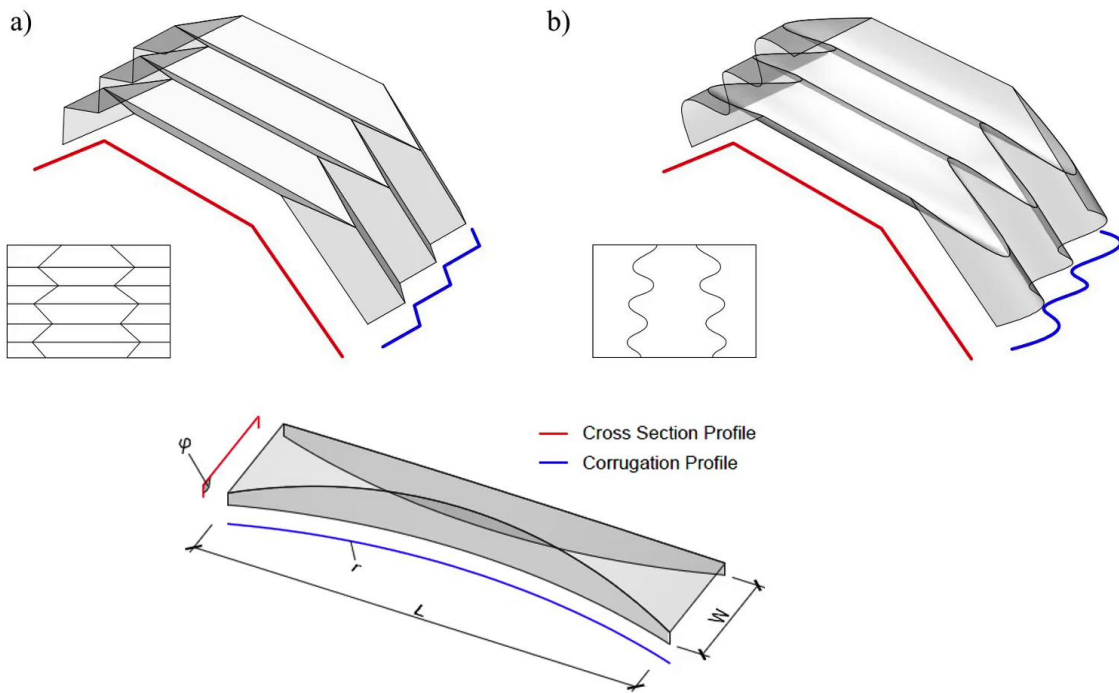


The use of such surface elements can also improve safety considerations concerning accidental fire, since a prismatic section of a truss of traditional carpentry, for instance, it can be replaced by a multitude of surface elements, panels, which act socially and as described both, retaining the structures overall integrity over when sustainably damaged.

Notes

Summary





■ Advanced Timber Plate Structural Design

Timber fabric.

Notes

Summary



4m 39s



■ Advanced Timber Plate Structural Design

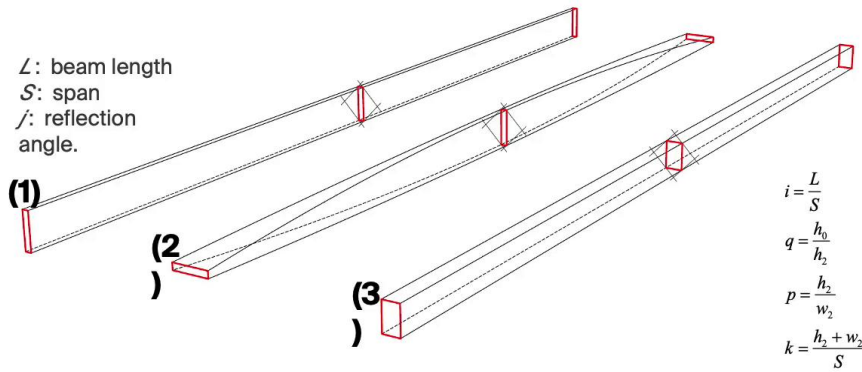
A possible perspective of those last ones may lie in the rethinking of construction techniques and the expansion of the former repertoire linked to the use of wood, while affirming the traditional values of timber construction. Together, its technical aesthetic and environmental appeal can contribute to encouraging an increase in the use of this material in contemporary construction.

Notes

Summary



4m 41s



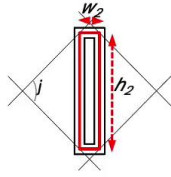
$$i = \frac{L}{S}$$

$$q = \frac{h_0}{h_2}$$

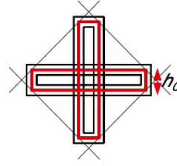
$$p = \frac{h_2}{w_2}$$

$$k = \frac{h_2 + w_2}{S}$$

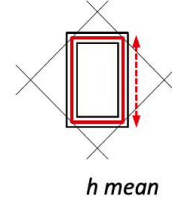
(1)
 $i = 1.1$
 $q = 1$
 $p = 17/3$
 $j = 90^\circ$
 $k = 0.05$



(2)
 $i = 1.1$
 $q = 1/p$
 $p = 17/3$
 $j = 90^\circ$
 $k = 0.05$



(3)
 $i = 1.1$
 $q = 1$
 $p \approx 1.609$
 $j = 90^\circ$
 $k = 0.05$

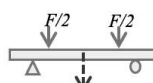





The combination of the ingredients timber, textile, fabrics and civil engineering structures underlined in timber construction has the potential to generate free-form structures which have literally no counterpart today.

Notes

Summary





	4 m		8 m	
Prototype	Deflection* (mm)	Maximum load (kN)	Deflection** (mm)	Maximum load (kN)
(1) 	16.3	9.6	14.3	
	15.9	9.1		
	16.7	9.0		
(2) 	17.7	8.2	15.0	> 37.2
	16.5	10.4	15.4	> 35.9
	17.1	9.5	15.6	> 35.6
(3) 	23.9	7.9	20.3	
	23.6	8.1		
	20.8	8.1		

* $F = 2 \text{ kN}$

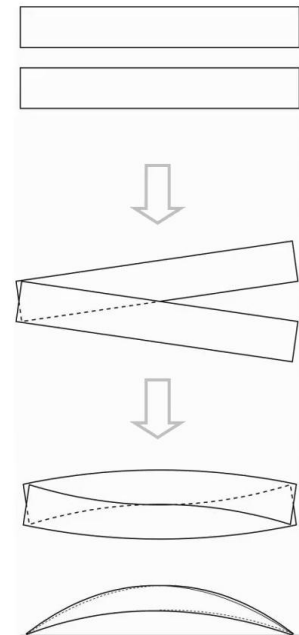
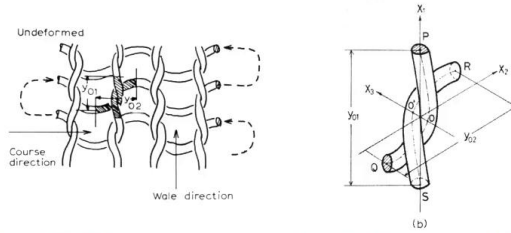
** $F = 4 \text{ kN}$

All timber is basically composed of a multitude of cellulose fibers.

Notes

Summary





Advanced Timber Plate Structural Design

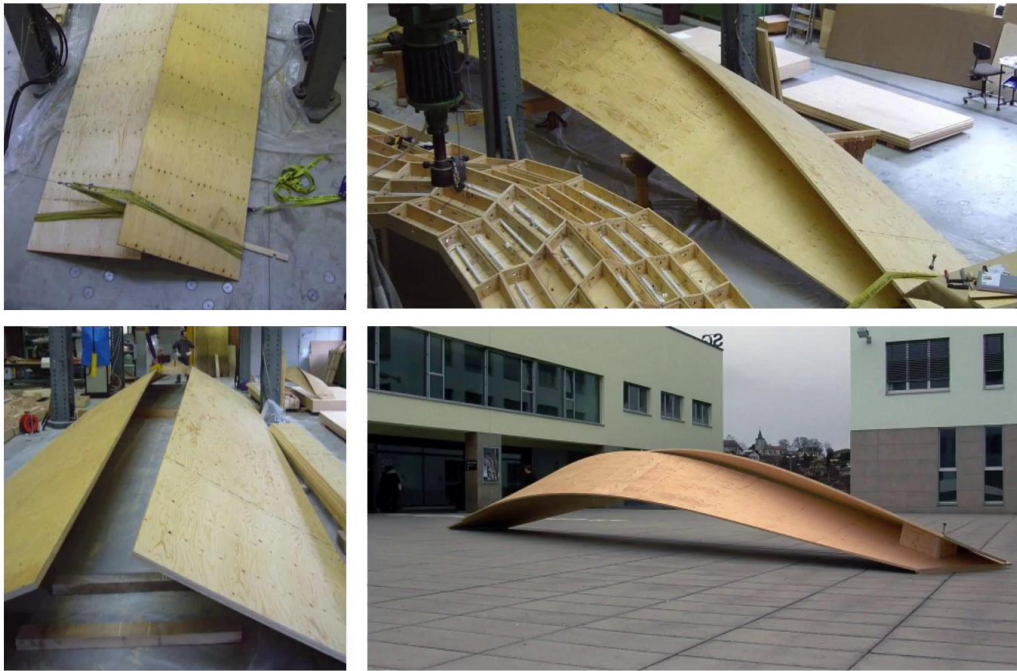
Those smooth fibers are flexible, allowing curvature. Such properties suggest that building scale woven flexible timber structures should offer exceptional performance in resisting seismic instability as well as extreme wind or snow loads. To date, the potential for building scale woven structures to significantly reduce the risk of structural collapse in the face of such challenges has not been systematically explored. The capacity to impose curvature, for example, on glued laminated timber beams has not led to a broader interpretation of that property for timber until now, but the implications are profound. In fact, timber has the dual capacity to be formed and to retain an imposed form.

Notes

Summary



5m 25s



The application of textile principles to timber constructions at the building scale allows to take advantage of this possibility to produce durability curved timber elements.

Notes

Summary



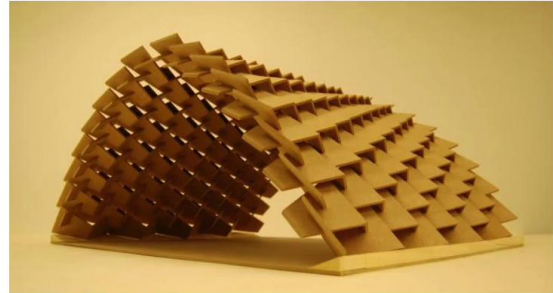
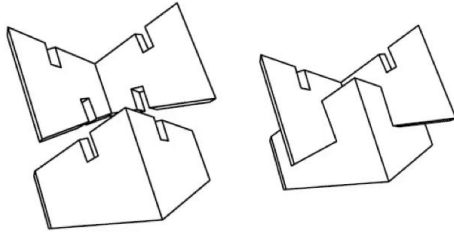


Timber is on the point of becoming amenable to the real realization of highly complex woven structure systems, where an important number of interactions of pieces of relatively small size constitute robust large-scale structures.

Notes

Summary



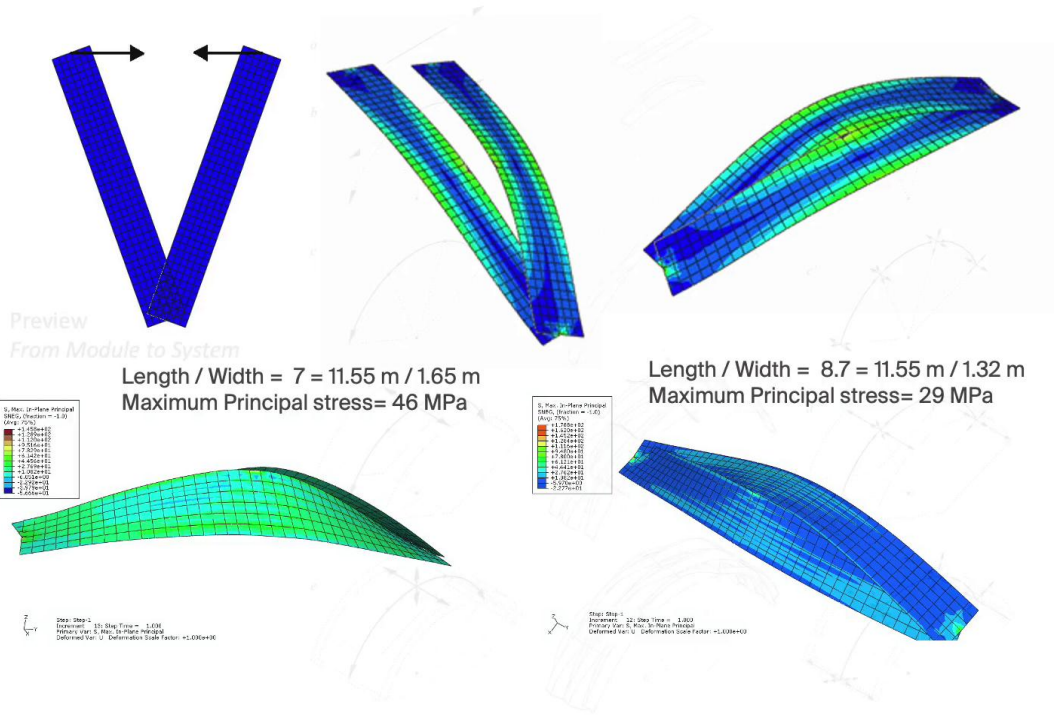


This can satisfy efficiency of production and safety considerations, combining aesthetic quality such as lightness and light transmission with functional quality, such as desired degree of rigidity or flexibility.

Notes

Summary



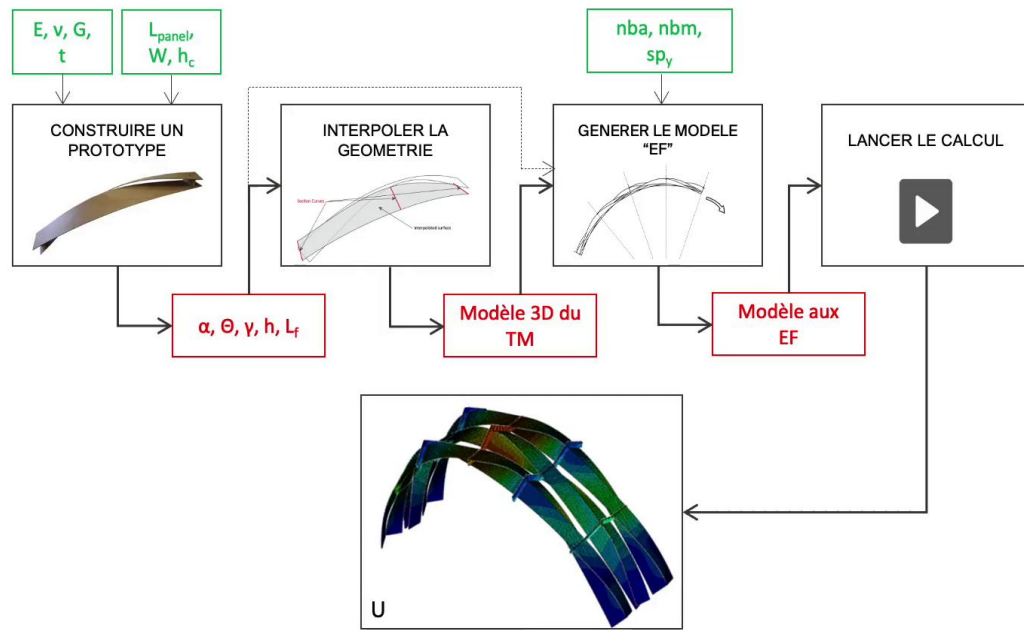


Particular attention is put on the design of form-active surface structures with engineered timber panels. A right range of geometries ranging from simple configurations to complex forms is essentially investigated. Those forms typically lie in the category of spatial structures. Through custom developed programs, the design and fabrication of structures with many geometrically different plates, were made possible. For its design, a digital workflow was applied from the geometry definition to the direct transfer of data for fabrication to all components of robotic fabrication.

Notes

Summary





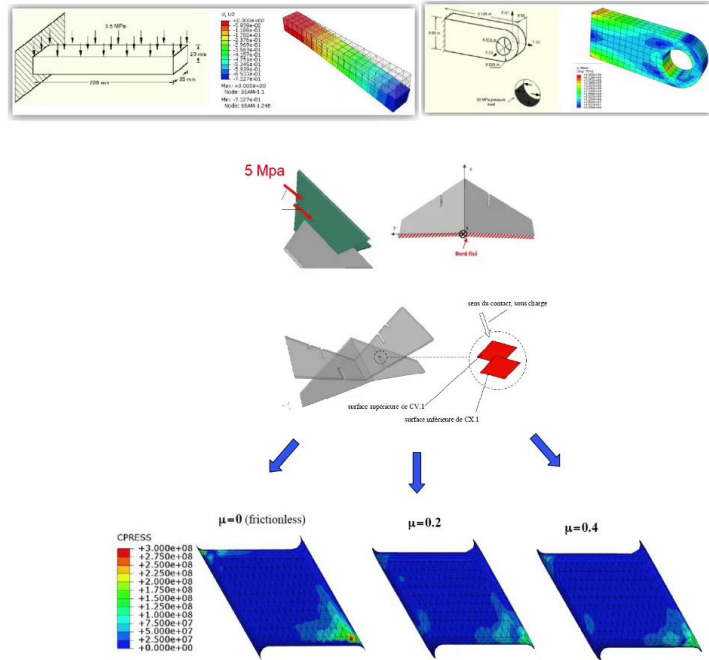
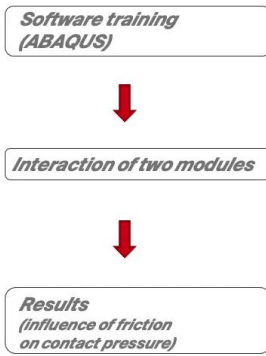
■ Advanced Timber Plate Structural Design

Those structures were built following an integrative strategy to combine design, engineering and fabrication to allow computational feedbacks and to transfer the complex geometry to finite element software and modify the design according to the results.

Notes

Summary



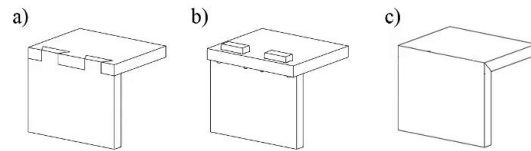


This is achieved by developing custom scripts, generating the machine code for the digital fabrication of the plates and the FEM model.

Notes

Summary

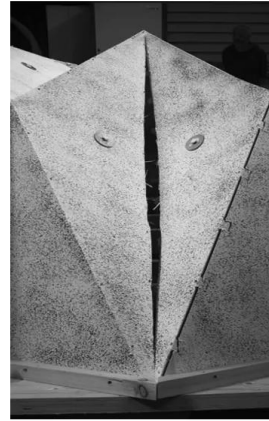




with open slots

with closed slots

Adhesively bonded connections



■ Advanced Timber Plate Structural Design

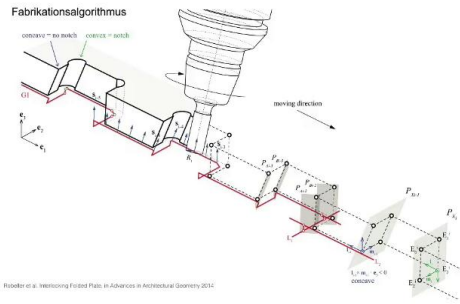
Fabrication.

Notes

Summary



8m 01s



Inspiration Tischlerhandwerk

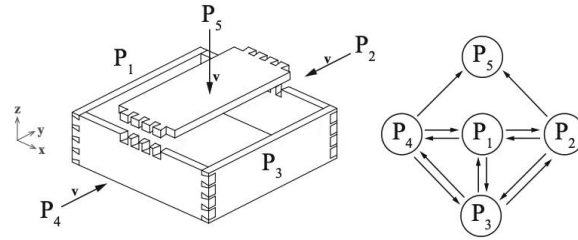
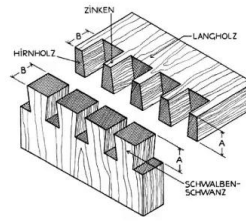


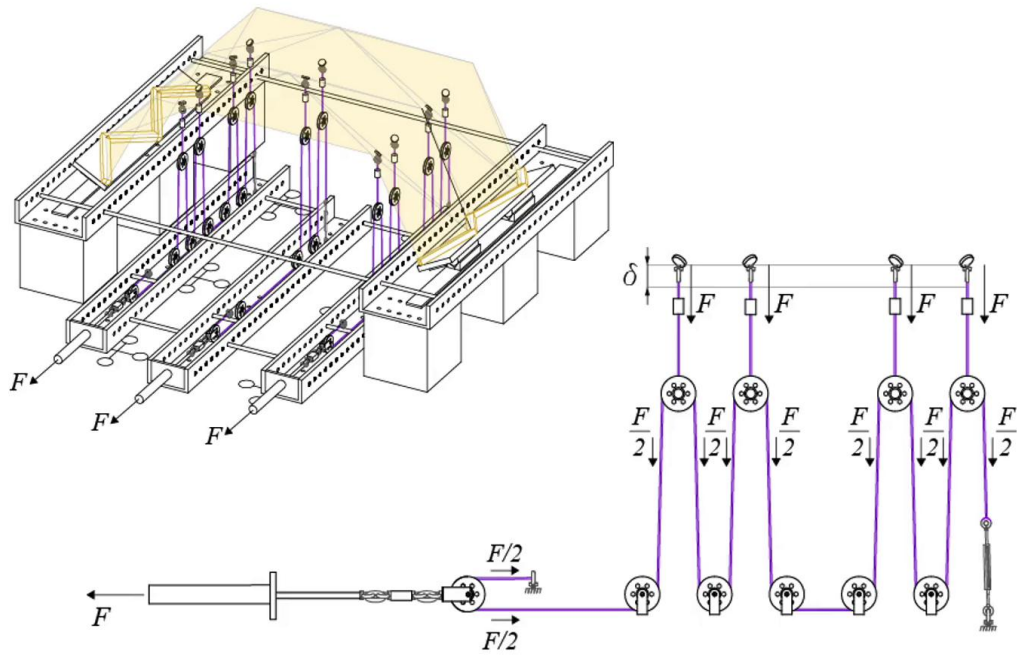
Figure 4.1 – This figure illustrates the mutual and hierarchical blocking of an assembly of multiple components through integral dovetail joints with only one degree of freedom.

The IMA technique is used to join timber elements with only wood-wood interlocking mechanism and without connectors.

Notes

Summary





To date, structural analysis has not been widely applied to timber construction as it had to steel or concrete construction.

Notes

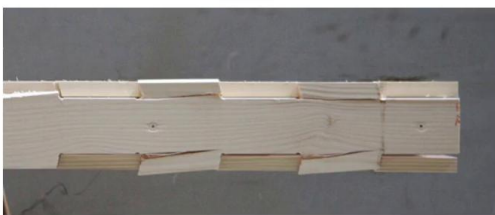
Summary



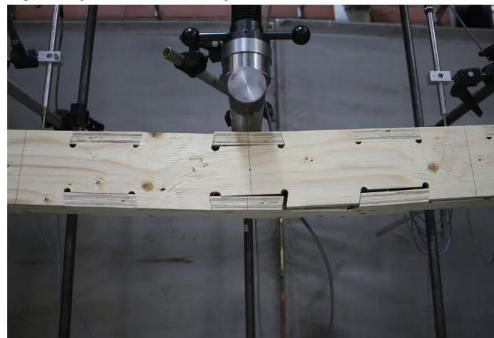
Spruce (solid wood)



Shear failure in the connection



Spruce (cross-laminated)



Failure in the panel

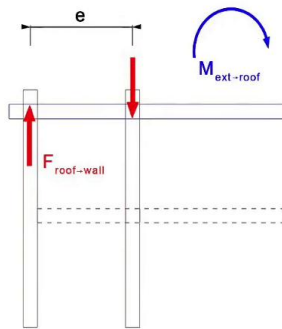


The proposed use of planar structural elements and curved linear elements made out of timber derived products will introduce timber in construction such as public buildings where architectural and aesthetic considerations are deemed to be of strong cultural importance.

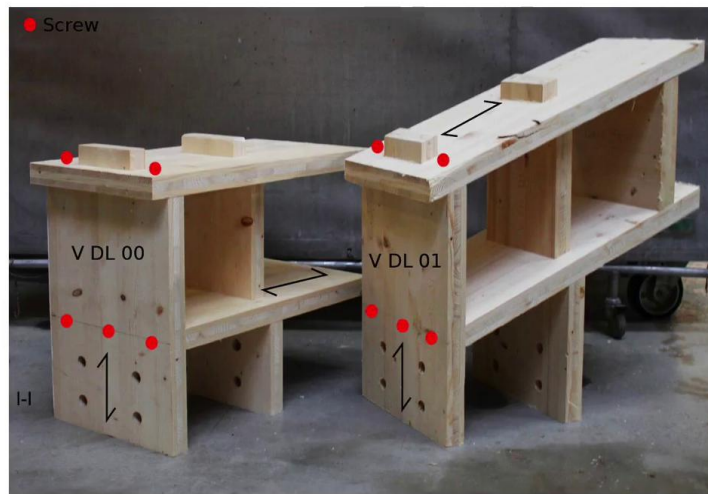
Notes

Summary





T_{Plate} 45 mm
 $T_{Structure}$ 300 mm



Other architecture applications are also possible but have not yet been sufficiently developed for industrial applications.

Notes

Summary



References

EPFL Doctoral Thesis, "Integral Mechanical Attachment for Timber Folded Plate Structures", Robeller, Christopher (student), Weinand, Yves (advisor). 2015.

EPFL Doctoral Thesis, "Integrally attached timber folded surface structures: geometrical, experimental and numerical study", Štitić, Andrea (student), Weinand, Yves (advisor). 2017.

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For example, one might envisage the industrial production of new classes of timber derived products such as woven timber walls and timber composites.

Notes

Summary

