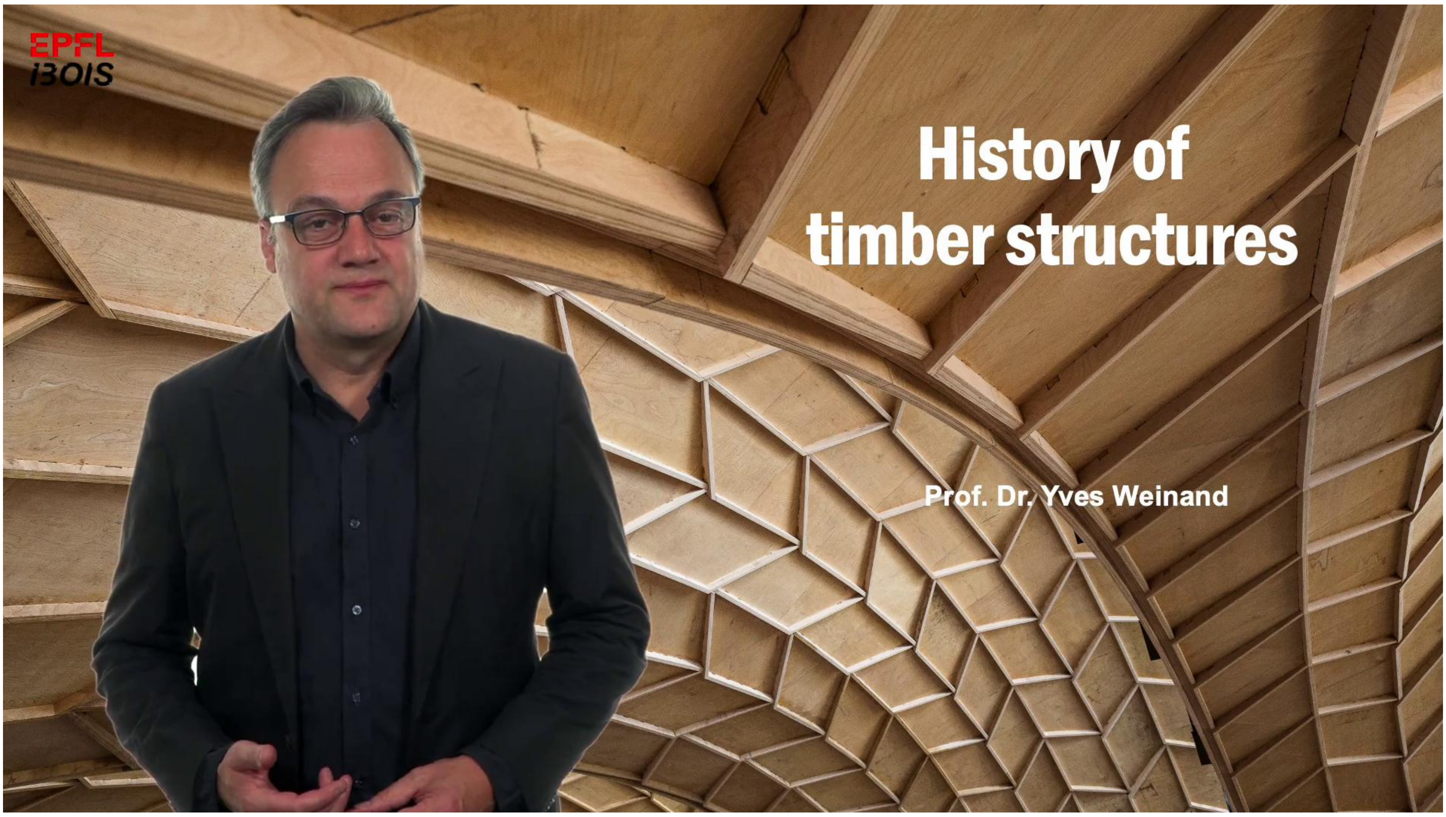
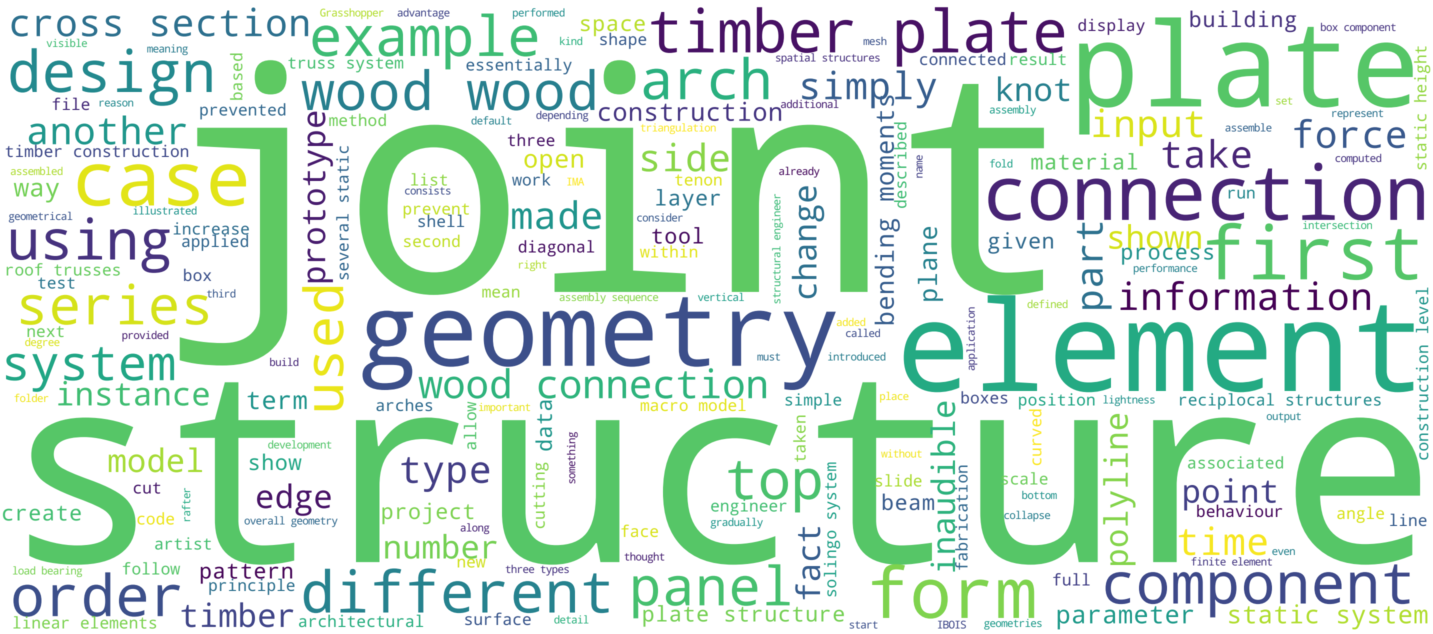
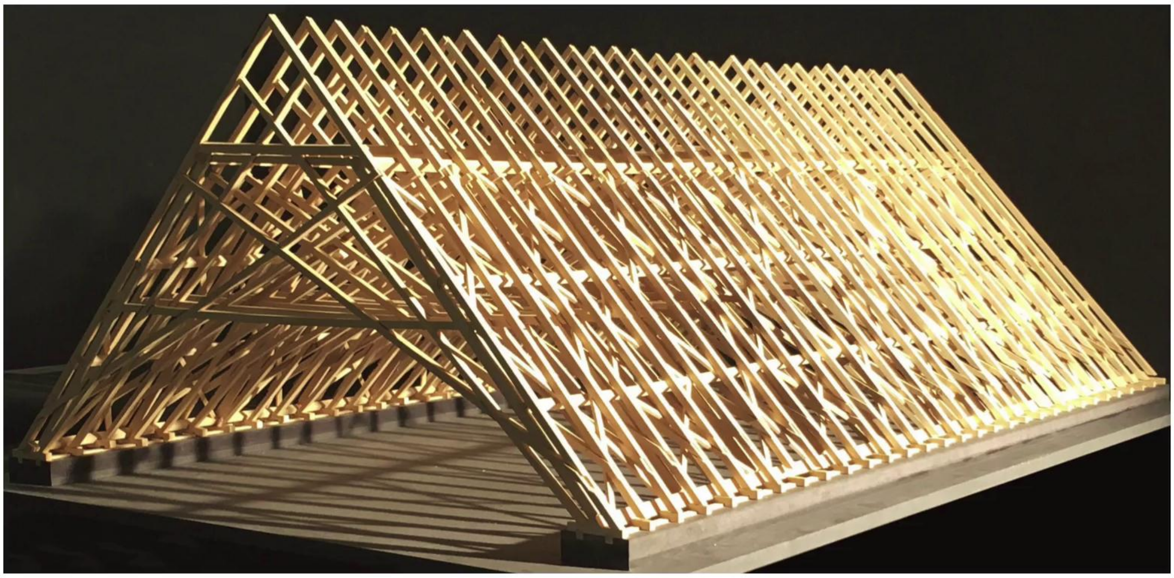




Search MOOC

Video

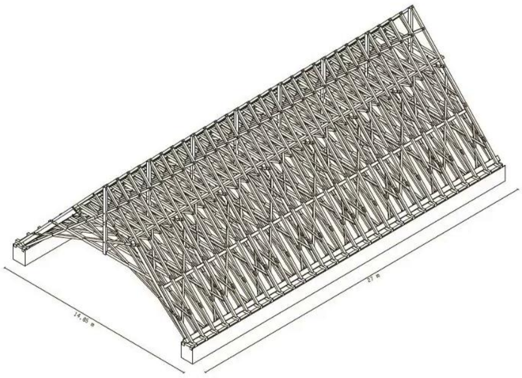


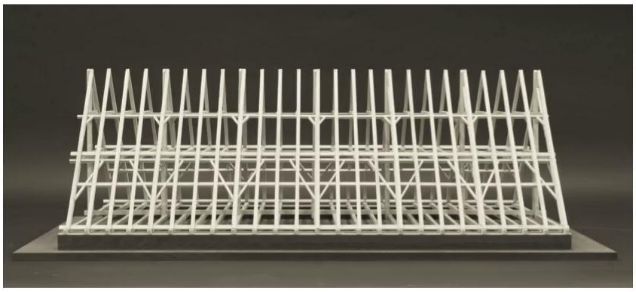
The innovative constructions of the Grubenmann bar still exert an enormous fascination on observers today. For what reason did we ask ourselves the question? After the inspection of the construction still present in St. Gallen, Switzerland, on site, a precise and detailed drawing of them was made. Only such a detailed recording reveals the possibility of analysing the construction methods present here of reconstructing assembly processes and of making also static considerations about them. The Grubenmann used long, slender and used very light components. This lightness was necessary. It had the advantage of being able to be built quickly and efficiently at height with the simplest lifting equipment and little labour. However, this lightness also had the disadvantage of providing relatively small cross-sections to absorb the forces. The circumstance led to an increase in the number of components in order to reduce the forces acting on them.

Notes

Summary

0m 04s





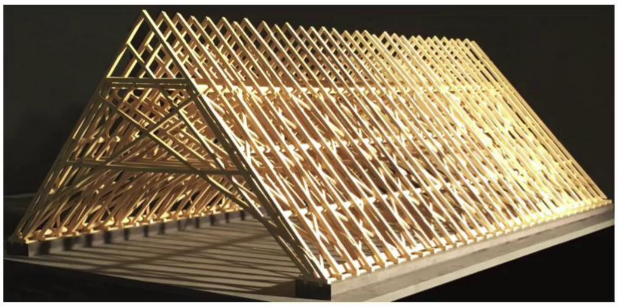
In all the roof trusses shown here, the center distance of the rafters is kept small and had a light truss system is added to each rafter level. Those additional truss systems are always designed in accordance with the rafter configuration. As a rule, a reinforced truss system is then proposed every four bays. Rafters and trusses form a cooperating load bearing system. Grubenmann superimposes two similar cross-sections and remains true to his basic idea of achieving overall stiffness over wider spanning systems by superimposing or layering many smaller elements. Superposition means that a larger cross-section is achieved by placing two smaller cross-sections on top of each other. But superimposition can also be wrapped into the overall geometry of the roof trusses, as here a multitude of small scale systems are combined to form an overall system. This layering of components which is very peculiar to the Grubenmann, occurs at all construction levels. In the vertical construction levels described above by superimposing the rafters with truss elements, but also laterally out of the truss level in order to achieve a favourable starting position for the formation of the nodes or timber wood connections in a new parallel and vertical construction level.

Notes

Summary

1m 16s

Prof. Dr. Yves Weinand

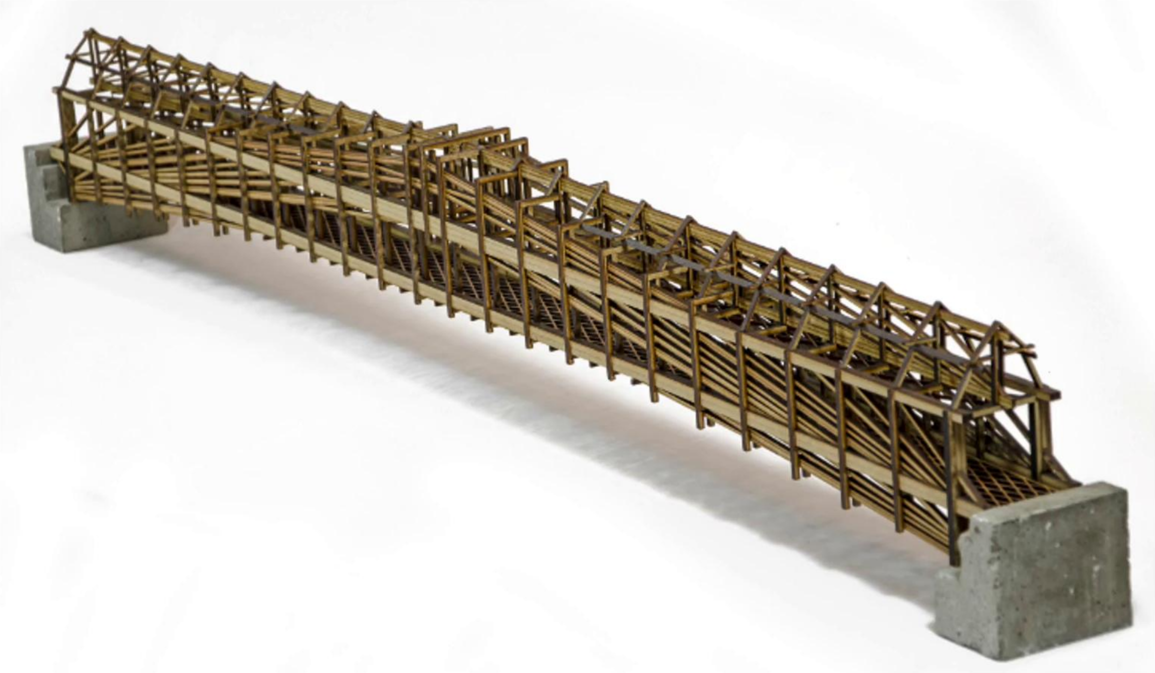


In individual buildings, one can observe how this additional plane is only partially one-third, one-half pushed out of the initial plane and enables connecting nodes to be formed in the middle timber. From today's point of view, this circumstance alone has been eliminated by the construction logic of trusses. Structural engineers understandably want to avoid local bending moments in truss constructions, and for this reason prefers center of gravity axis that converge at the node intersection. In fact, however, local bending moments are usually accepted to allow for the cutting and welding of pipe cross-sections of different sizes, for instance. Those considerations take place in one and the same vertical plane. Grubenmann creates a particular interesting situation by pushing out of plane as described above, which opens the way to mechanical node optimization for timber construction. This type of structural design is also of educational importance today of importance in general. The arrangement of the bars in space incorporating the concept of the wood-wood connection, challenges the structure in this design.

Notes

Summary

2m 59s

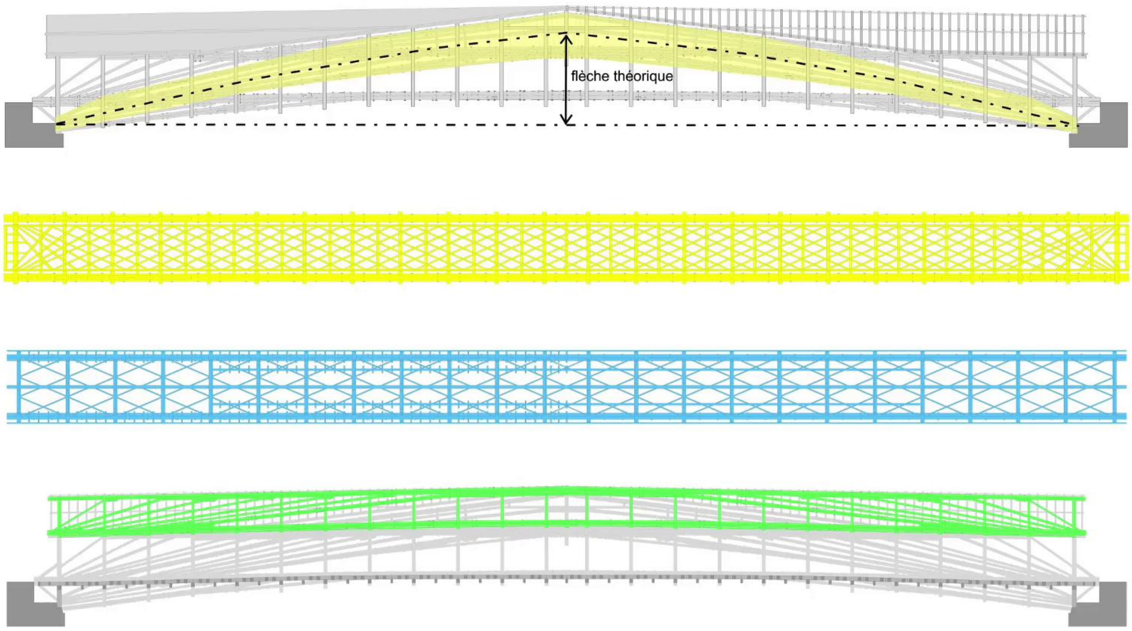


Those geometric dispositions created in space choose leads to optimize not situations in terms of structural engineering, but at the same time they give the Grubenmann's constructions their special plasticity and inherent aesthetics. This very important balance between constructive constraints on the one hand and static necessity on the other, characterizes the beauty of Grubenmann's constructions. Johann Ulrich Grubenmann 1709, 1783, was a Swiss carpenter who built numerous timber structures | and bridges throughout the 18th century. At that time, the basic strength of materials had not yet been fully established, and builders were forced to rely on their own instincts as there was no accurate dimensional verification method available. Grubenmann designed church frames in which he used both triangulated frame structures and elements that worked in the form of superimposed arches. Choose the overall behaviour of those structures can be described as hybrid.

Notes

Summary

4m 19s



The Schaffhausen bridge combines several static systems in one construction. The overlapping aspect is also reproduced on the scale of the actual construction element itself. To increase the static height of some of the main load bearing elements, rectangular wooden beams are stacked on top of each other, and their relative sliding on each other is prevented by means of multi-splice connections made out of wood. In this type of connection, sliding is prevented by the wood-wood contact. In effect, the teeth of the joint will mobilise areas of contact in compression. Grubenmann also revisits the classic tongue and groove joint by proposing multiple teefs since he is dealing with very long pieces. We see one of the characteristics of contemporary architecture, hybridity already present in the work of the Grubenmann brothers. Indeed, the super imposition of several static systems in a single structure and their intuitive assembly ultimately gave the Schaffhausen bridge a vernacular character. It can be said that such constructions were no longer carried out during the 19th century because the means for their design were not available. Hybrid, complex superimpositions of static systems or models visibly disappeared from the repertoire of the newly emerging profession of the engineer Depon Dehose.

Notes

Summary

5m 39s

EPFL IBOIS

Advanced Timber Plate Structural Design

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The latter increasingly separated himself from an intuitive understanding of construction and took the rational path of simplified constructions, which were, however, also measurable. The reconstruction of Grubenmann's roof trusses is a vivid example of the fact that the profession of engineers and that of an artist could be identical and that the innovations of the artist-engineers in the Baroque area actually produced structures that required and represented technical and artistic knowledge. In equal measure, Herbert Lachmeier writes, in the service of the machinery of progress, the creative inventiveness ingenium of the engineer, and the scientist can only be called innovative if it follows the given rules. Ingenium is domesticated as a nature talent and an innovative spirit derived from the latingenery to bring forth, to produce into that force that is only able to become creative to rigid training and many years of discipline. In the 17th century, Francis Bacon still had the common concept of imaginatio between artist and engineer as a basic creative ability. Later, the two enter into competition. The creative spirit of the scientist inventor or an engineer is thought to be different from the imagination of the artist.

Notes

Summary

7m 27s

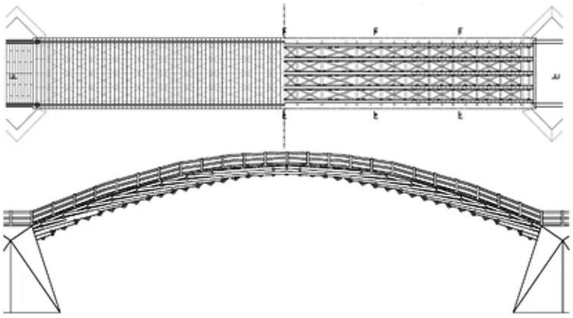
Prof. Dr. Yves Weinand

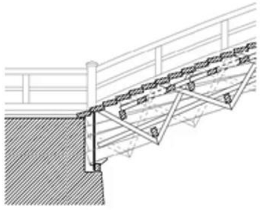
The reconstruction of those trusses is the welcome occasion to show that in Grubenmann's time the creative spirit of the scientist, inventor and technician could be taken for one. This is certainly a very important observation when one considers the development of the civil engineer in modern times.

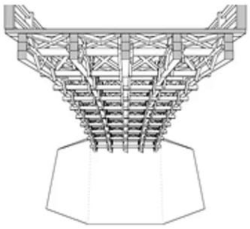
Notes

Summary

9m 16s





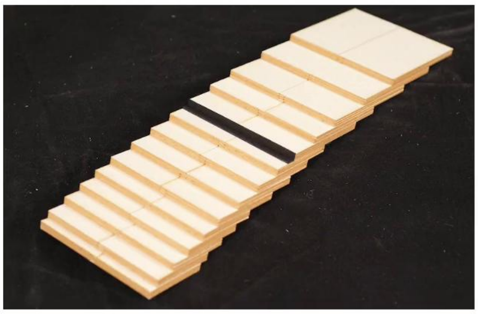


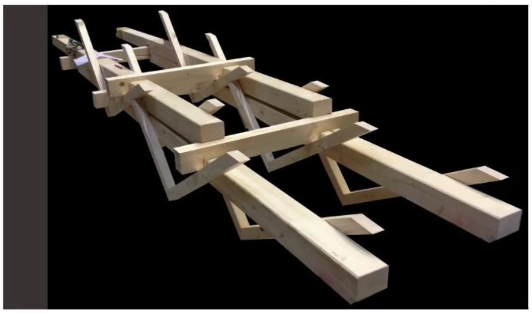
The Kintaikyo Bridge in China, the Japanese designers reacted differently to the need to prevent slippage between the different layers of the Kintaikyo curve bridge deck than Grubenmann did. The designers wanted to build an arched bridge without the use of curved elements. To form the main curve, an innovative overlay system was devised. This also forms a staircase on the upper side. To prevent those overlapping elements from slipping, several types of connections are placed in parallel. Recesses are provided in the longitudinal late parts and cross-pieces which fill those recesses. Also, those cross-pieces are very visible and give the bridge a spatial appearance, they are not mechanically effective connectors. Since wood has very little resistance to shear stress as it works perpendicular to the fibres, those cross-breams would have split very easily if additional connectors had not been used. The manufacturers had provided an additional system of diagonals, which is attached to the face of the composite element.

Notes

Summary

9m 41s



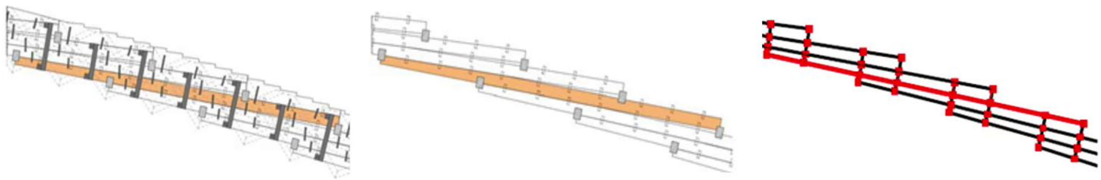


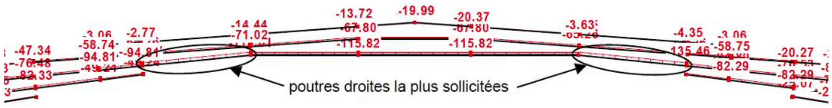
This system of arches is then repeated transversely. Some elements, the cross-beams, but also the steps, correspond to the width of the bridge. Further triangulations are added in the transverse direction. In summary, the construction represents a compact and coherent whole where each part fulfils a specific role. Also, those roles may be constructive, static or a mixture of both. In this example, the overall form is born, or at least results from the invention of an additive constructive system. The constitution of the arch from linear elements is in itself an original invention.

Notes

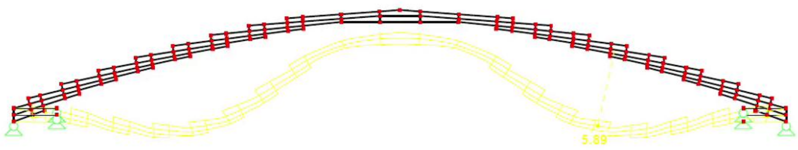
Summary

10m 52s





V_{Ed} = 135.47 kN



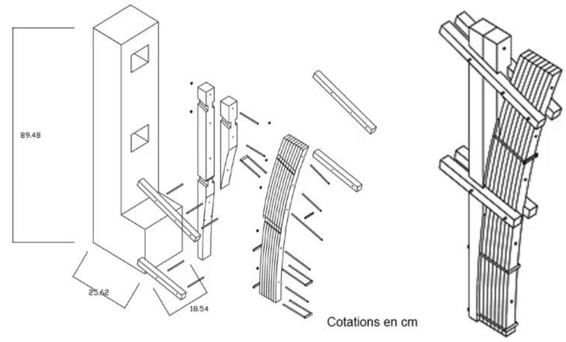
w_{Ed} = 5.89 mm

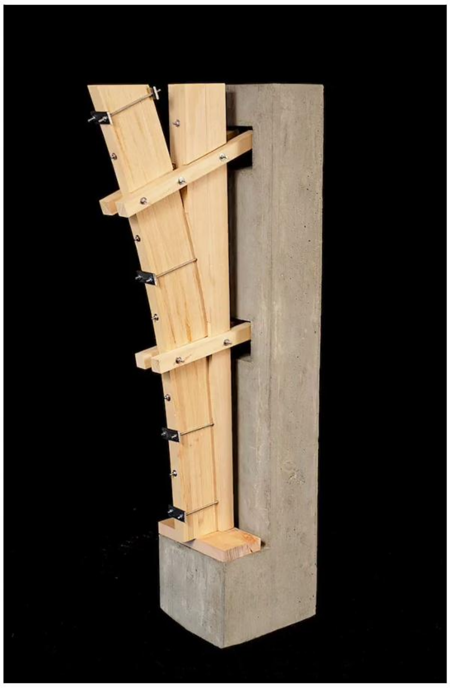
It is not the result of a structural logic since the fibers in those rectangular parts do not follow the line or force of the arch, which may seem incoherent. The assembler presents a particular structural model in which several static system coexist.

Notes

Summary

11m 33s





In 1820, Colonel Amy from the French Army proposed a system that today bears his name. The boards are let horizontally stacked on top of each other and given a curved shape. Arched structures are too created in this way. They allow larger spans to the bridge here too. The relative sliding of the planks had to be prevented, and Amy used three types of connections for this purpose. Notches are made in the outer faces of the arches. Those allow diagonals to be attached. Those diagonals have a double function. They prevent the stats from sleeping relatively to each other, but they also act as diagonals in an Apa static system which is a lattice gridder with the recomposed arch as the lower short and the double sloped roof of the riding hole as the upper short. Pins sperse the arch at regular distances. U-shaped clamps provide additional support from the outside. Together, those three types of connections increase the flexural rigidity of the arch without, however, reaching that of a solid rectangular section. The lattice girder mentioned above also represents hybrid zips and hybrid system of a variable inertia and partially triangulated girder. In fact, its static height varies, the cross-sections of its members vary, and the triangulation of its openings is only partially ensured leaving quadrilateral rather than triangular openings.

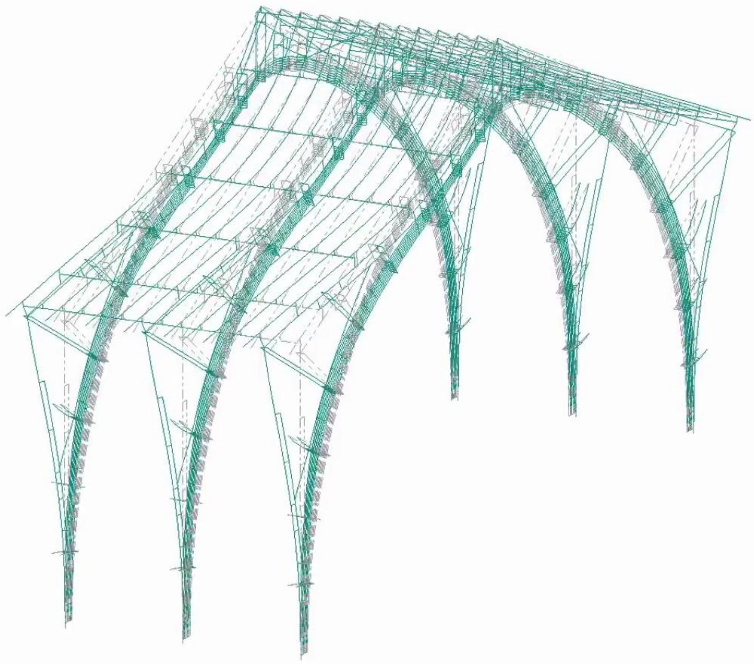
Notes

Summary

11m 52s

EPFL
iBOIS

- Mode Propre 3 :
  - Fréquence : f_3=4.28 Hz
  - Période : T_3=0.24 s



Animation du mode propre 3

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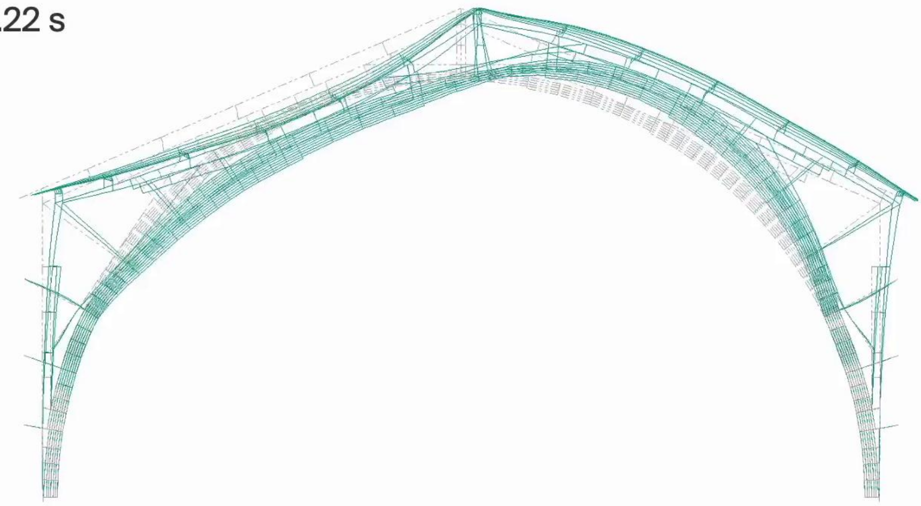
This structure prefigures the principle of glued laminated timber, which is based on the superposition of several wooden slats actively glued together in order to prevent the sluts from sliding relatively to each other.

Notes

Summary

13m 34s

- Mode Propre 4 :
  - Fréquence : f_4=4.64 Hz
  - Période : T_4=0.22 s



Animation du mode propre 4

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It also pre-figures the principle of ripped wooden shells.

Notes

Summary

13m 48s

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- Risque de flambage de l'arc.

Animation du Flambage d'un arc

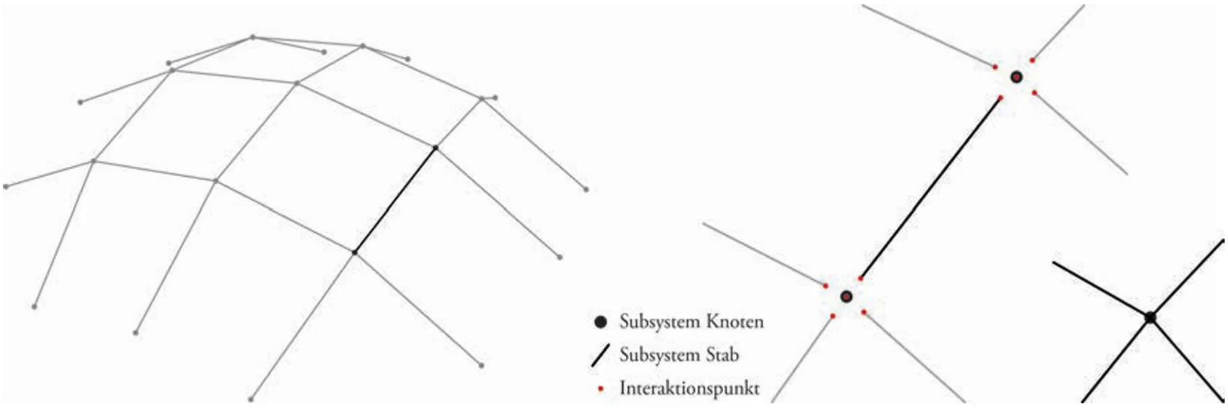
Advanced Timber Plate Structural Design

The latter system transposes the principle invented by Amy into the space or into spatial structures.

Notes

Summary

13m 53s



From there, engineers developed spatial structures, while they were very concentrated on the notion of a knot and what that could physically become. A knot is an intersection of several linear elements, lines, mathematically speaking, but in reality, a knot becomes a physical expression of a volume.

Notes

Summary

14m 01s

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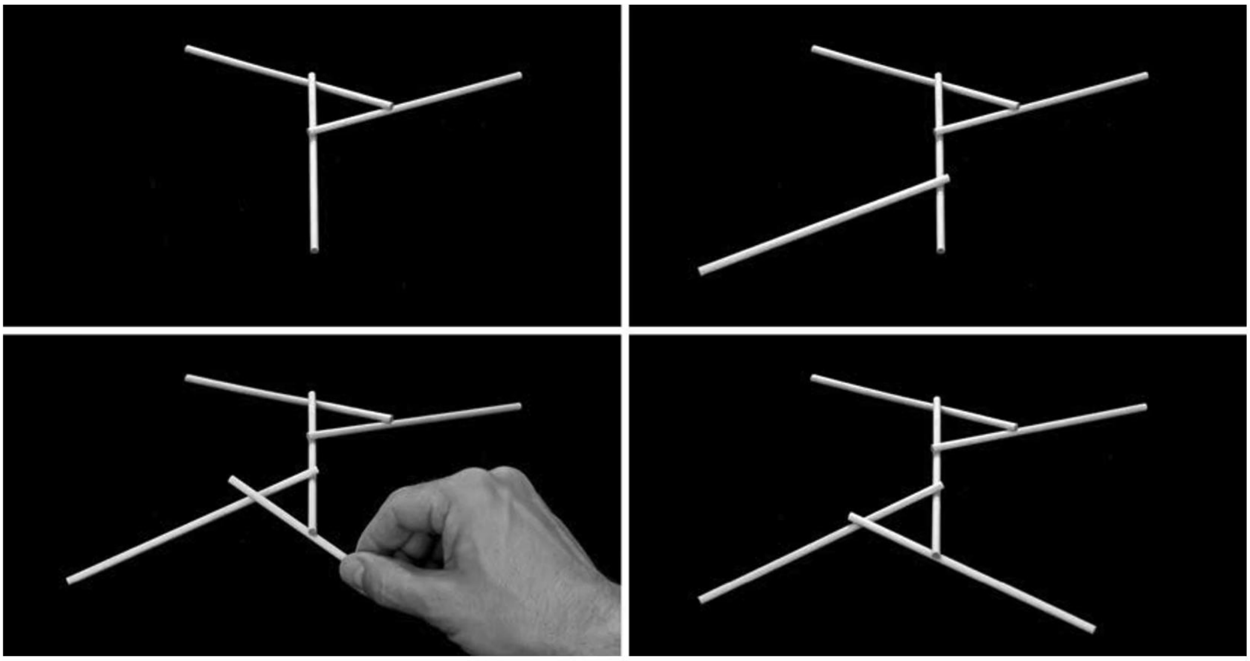
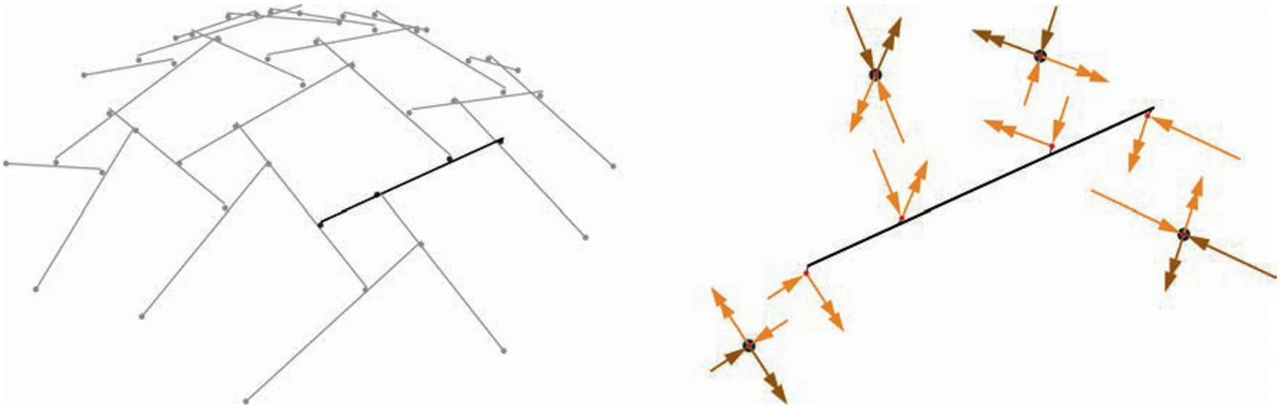


So we were very interested in reciplocal structures because instead of connecting a large number of elements into one single point, reciplocal structures allow for displacing those points and duplicating knots because of the reciplocal approach they are geometrically using.

Notes

Summary

14m 28s



This is illustrated here in a spatial application and also illustrated in several research works where you can then introduce bending moments into those beams, but the intensity of those bending moments can be limited.

Notes

Summary

14m 52s

EPFL
iBOIS

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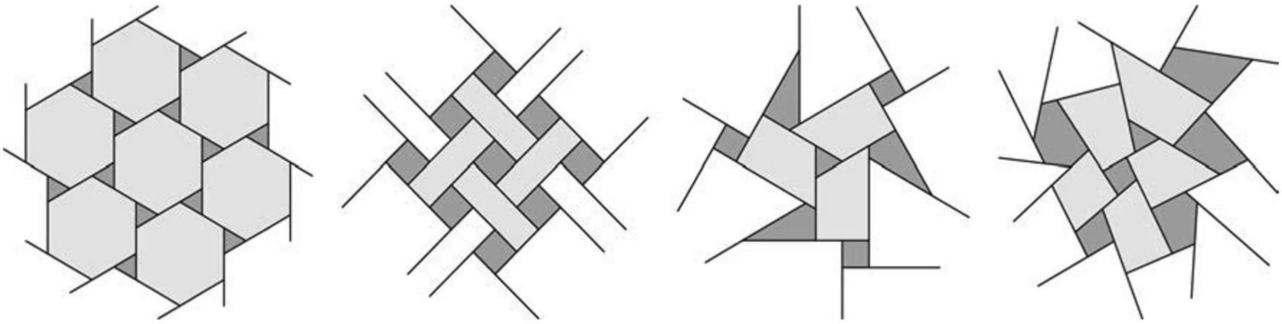
Advanced Timber Plate Structural Design

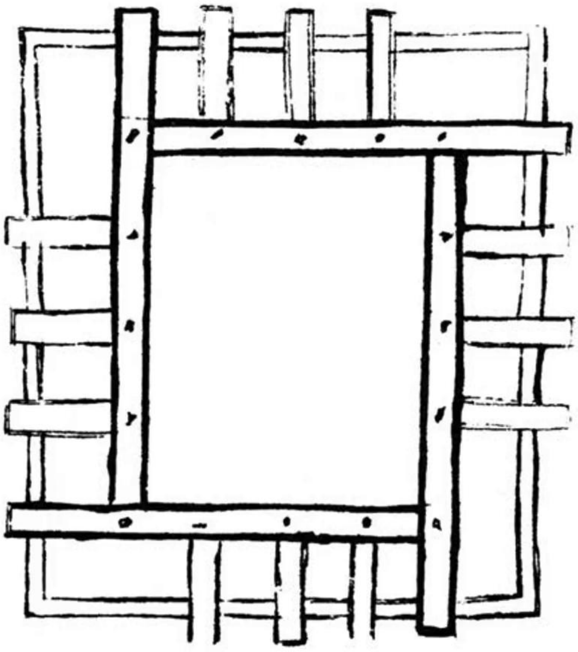


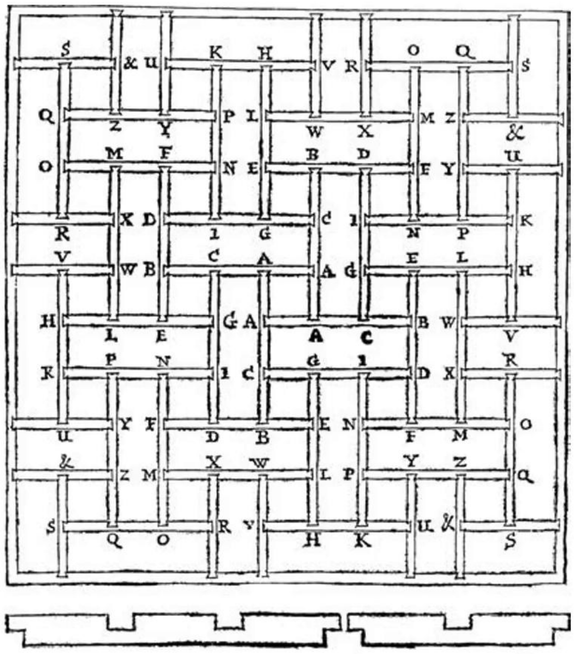
More importantly, it opens also thoughts for design solutions which could introduce sophasic structures or sophasic bearing elements. Meaning that reciplocal structures show linear elements or can be used by beam structures, but reciplocal structures could also be expressed in terms of its geometrical patterns by sophasic structures.

Notes

Summary

15m 13s



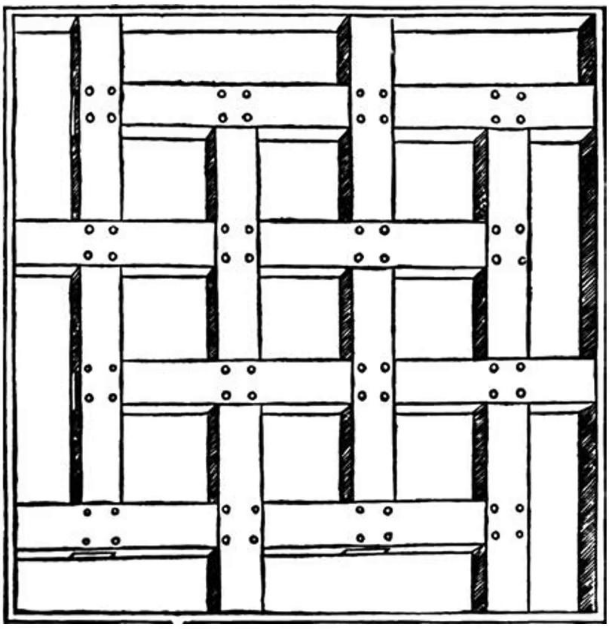


The solingo system. The polygonal spatial mesh known as the solingo system allows the creation of spatially discrete structures that can take the form of a polygon.

Notes

Summary

15m 46s

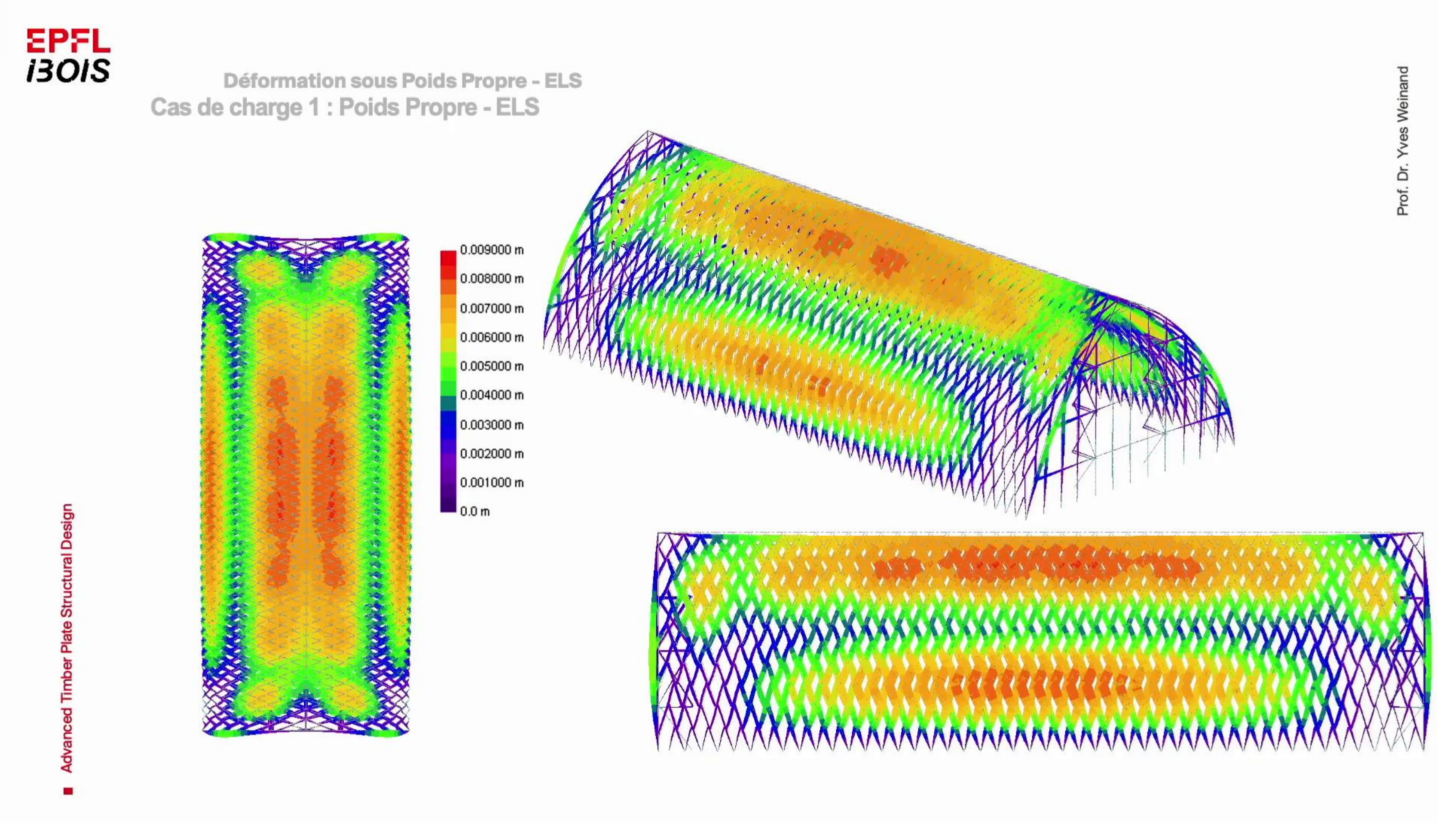


Solingo, abonon is the classical continuous truss primary system, and praline secondary system, in favor of a system that truly works in space.

Notes

Summary

15m 58s

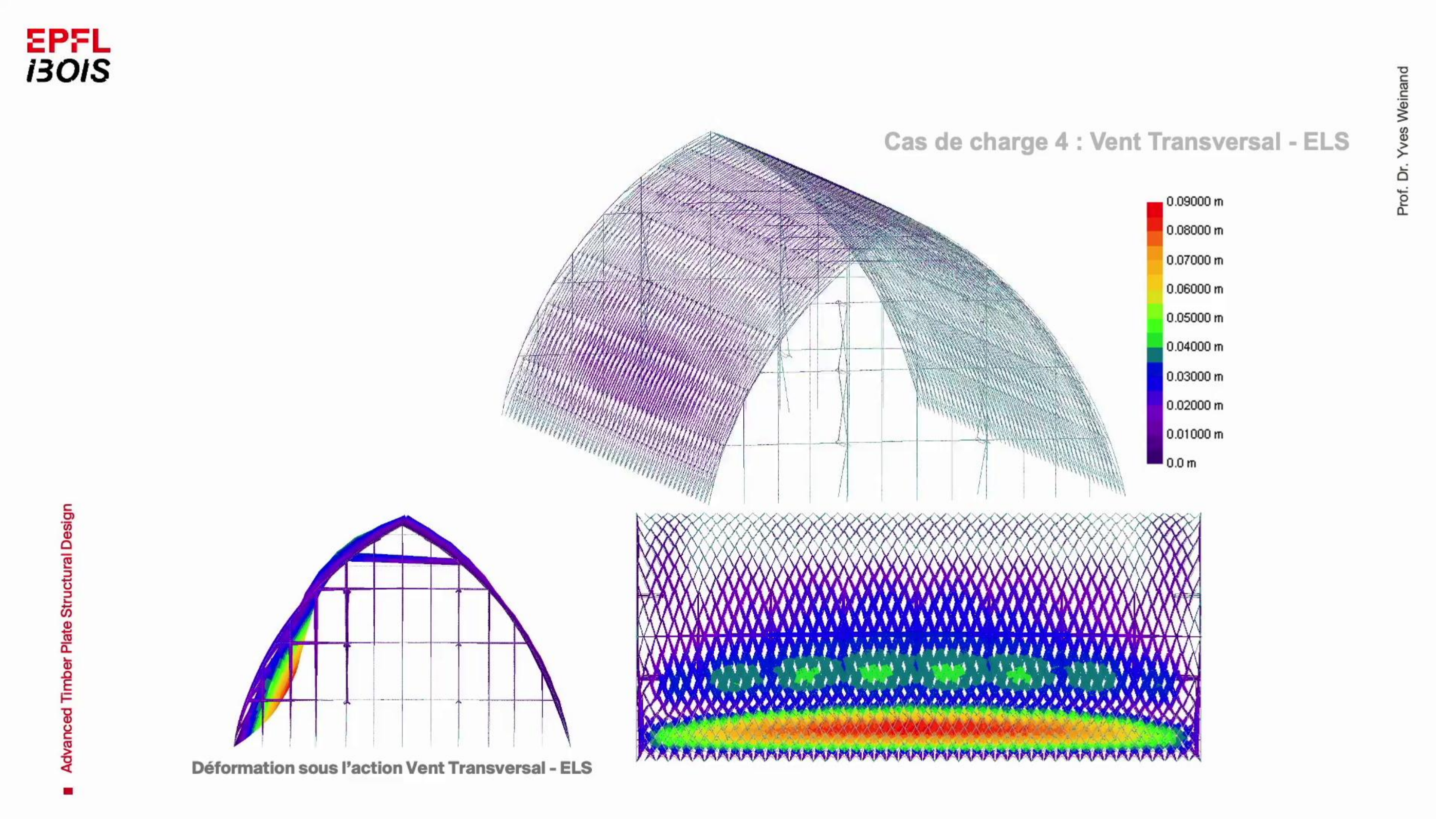


The overall geometry of this polygon appears particularly fluid. Each knot is crossed by another bar with the other two bars are interrupted as the knot but slightly offset. It is therefore a form of reciprocal geometry. The solingo system has many advantages. The entire structure is constructed using small parts and is therefore easy to transport and assemble. The structural elements are hardly weakened at the knots, as is often the case in conventional timber construction. Only a small hole is made.

Notes

Summary

16m 08s

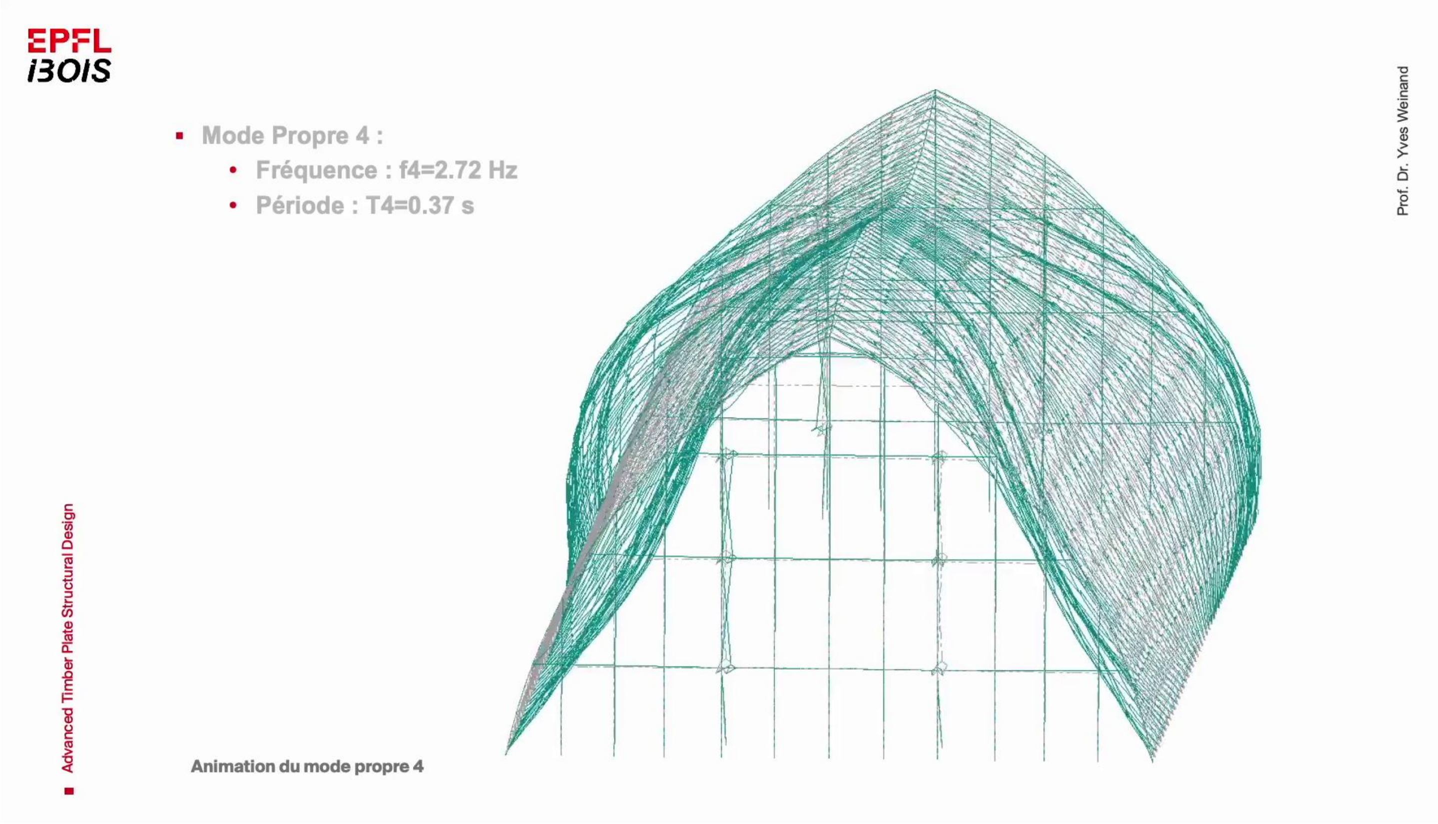


The structure has an efficient structural mesh since the collapse of one part will never cause the collapse of the whole structure.

Notes

Summary

16m 45s



Geometrically, the system can be adapted to different shapes such as volt or domes.

Notes

Summary

16m 54s