Advanced Research in Timber Construction

Laboratory for Timber Constructions

Yves Weinand | Professor

IBOIS | EPFL | Lausanne

IBOIS

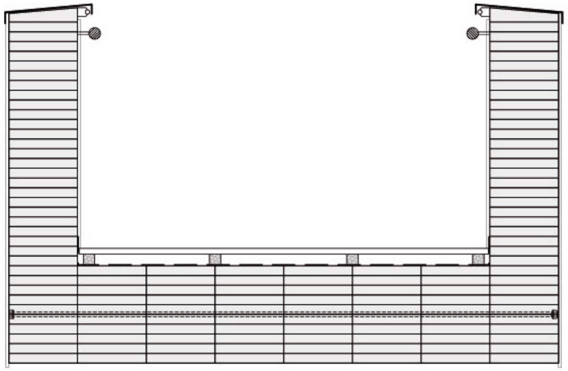
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Professional Practice
Teaching
Completed projects
Current research & projects

Summary

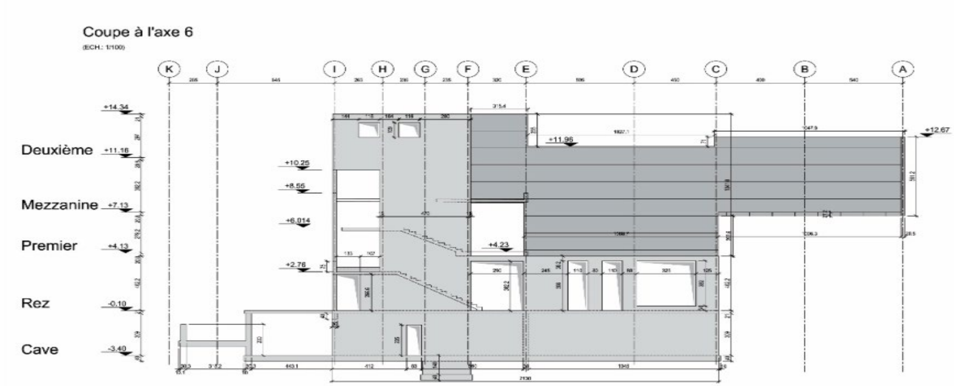
Professional practice

Professional Practice



2007 Pont pédestre sur l'Our,
Burg Reuland
Maître d'ouvrage : Commune de Burg-Reuland
Architecte: association momentanée Michaelis-Weinand, Espeler
Ingénieur: bureau d'études Weinand

Professional Practice



2009, Musée de la photographie, Charleroi
Maître d’ouvrage : commune française de Belgique
Architectes: Escaut architecture, Bruxelles
Ingénieur: bureau d’études Weinand

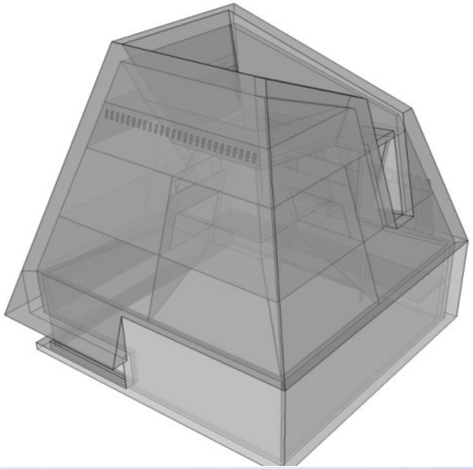
Client: City of Yverdon
Architect: Brauen&Wälchli with Yves Weinand
Structural engineer: bureau d'études WEINAND
Surface: 2'866 m²
Construction cost: € 14'000'000,-
Note: A three dimensional timber structure has been used in order to span over 48m.
The structure develops in space using all four facades as stiffeners.
Realization: 2009-2011

CENTRE SPORTIF YVERDON-LES-BAINS 2011

Bureau d'études Weinand - Ingénierie - www.weinand.be

Professional practice

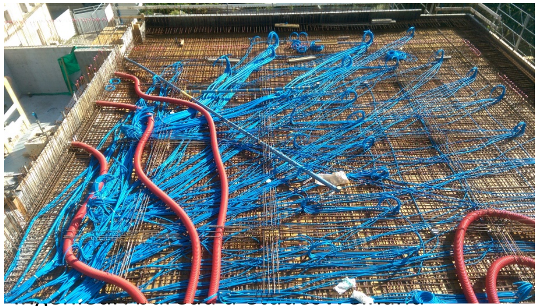
Professional Practice



2009, Parlement, Lausanne
Maître d’ouvrage : canton de Vaud
Architectes: Atelier Cube / Bonell & Gil
Ingénieur: bureau d’études Weinand

Professional Practice

Professional Practice



Professional Practice

Professional Practice

Reconstruction du Parlement vaudois

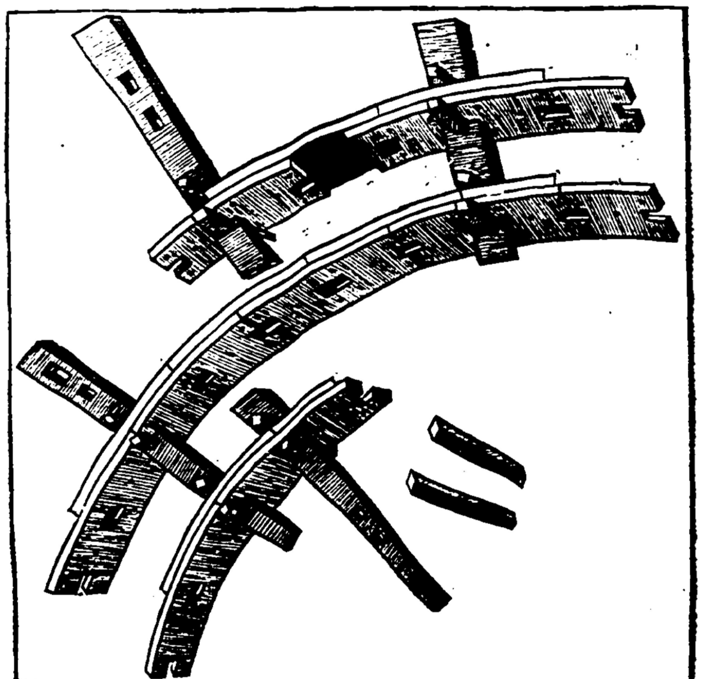
Montage de la toiture

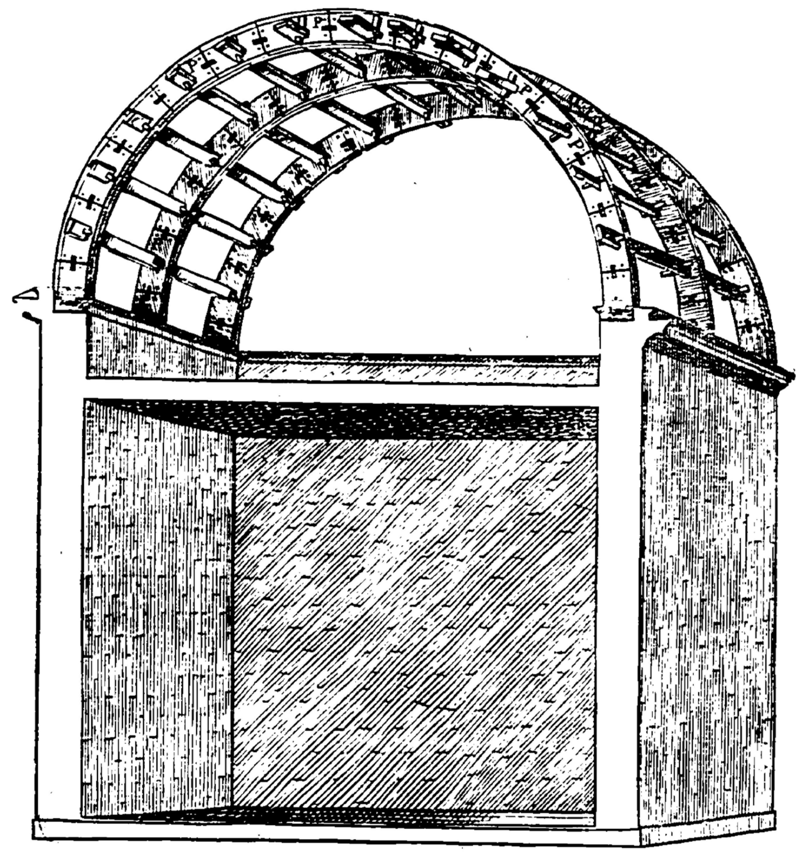
La Cité - Lausanne

Maître de l'ouvrage: Canton de Vaud
Architectes: Atelier Cube + Bonell i Gil
Ingénieur civil: Yves Weinand
Charpente: Groupe Volet

Philibert de l’Orme

Construction detail

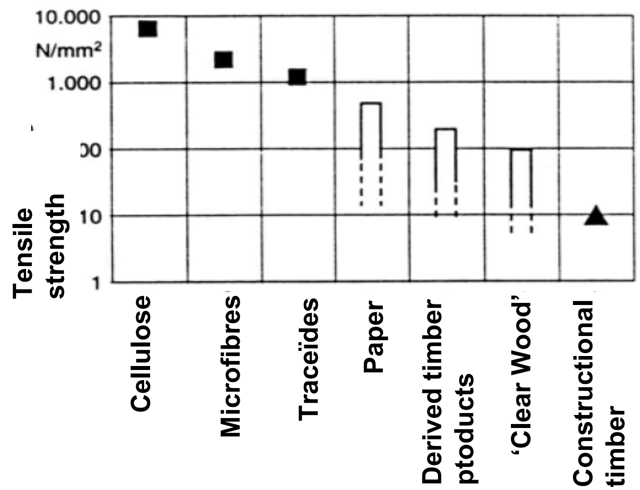


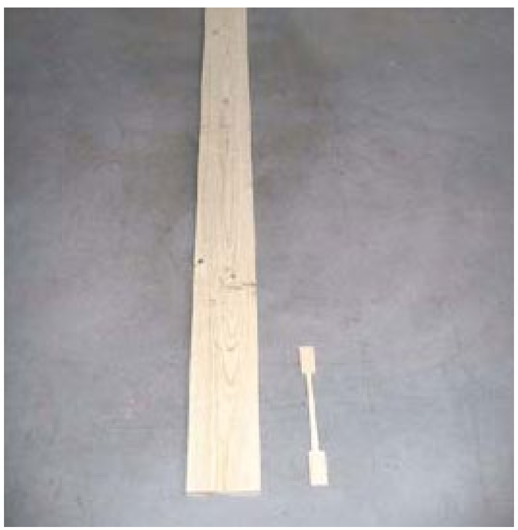


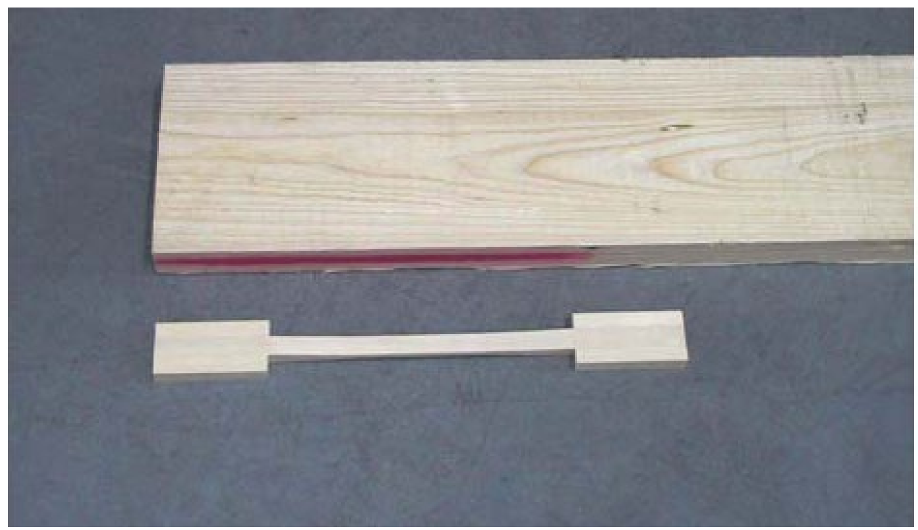
Caracteristic values of spruce
[P. Niemz, 1993 and P. Glos, 1981)

Characteristic properties	Small Specimen	Constructional Element	Difference to the small specimen
Bending Strength (mean value [N/mm2])	68	37	46%
Tensile Strength parallel to fibers (mean value [N/mm2])	80	30	63%
Compression Strength parallel to fibers (mean value [N/mm2])	40	32	20%

Mecanical Properties [Glos 1999]







Professional Practice

Teaching

Conception des structures

Grubenmann Project

Study of a Pavilion for Vidy

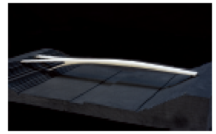
Previous Research & Completed projects

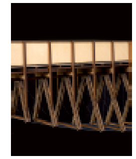
Current Research & Applied projects

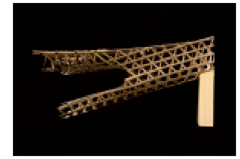
Forme versus structure


Passerelle Traversina II, Jürg Conzett, 2005.


Passerelle Traversina I, Jürg Conzett, 1996.

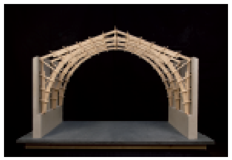

Passerelle piétons PS0, Marc Mimram, 1988.





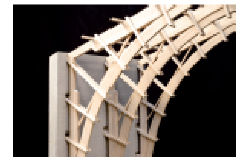
Deux démarches sont illustrées à l'aide d'exemples de ponts conçus par les ingénieurs Conzett et Mimram. Les deux premiers exemples décrivent une situation où la pensée structurale a généré la forme du pont. Le troisième exemple présente la situation opposée où l'objectif d'une forme a donné lieu à la structure.

Eléments composés travaillant en flexion


Système EMY, Colonel Emy, 1830.

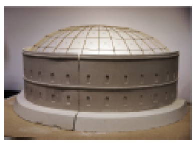

Pont Grubenmann,
Hans U. Grubenmann, 1755.

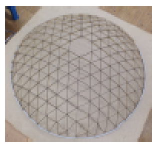

Pont Kintaikyo, 1673.

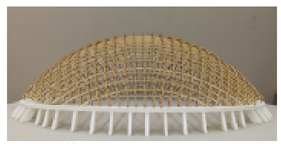


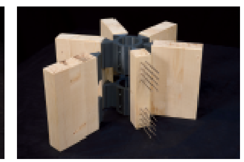
Le système Emy, les frères Grubenmann et les auteurs du pont de Kintaikyo ont tous eu recours à la fabrication d'éléments composés de plusieurs couches et travaillant en flexion.

Structures de dômes


Réservoir de gaz, J.W.Schwedler, 1874.


Dépôt de sel, Häring, 2012.

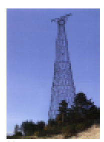

Dôme d'Odate, Toyo Ito, 1997.



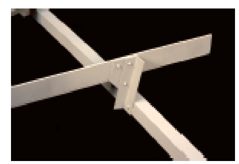
L'ingénieur Schwedler et l'ingénieur Häring ont construit en 1874 et en 2008 des structures de dômes répondant à des principes de subdivisions classiques en parallèles et en méridiens d'une part et en triangles réguliers d'autre part. Un troisième type de dôme issu d'une réflexion sur la lumière et la topographie se voit illustré par l'architecte Toyo Ito en 2009.

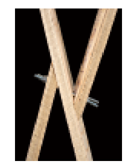
Structures spatiales


Pont Tschapti, Monovolume, 2000.


Tour de ligne à haute tension,
Vladimir Shukhov, 1929.


Gut Garkau, Système Zollinger, 1926.

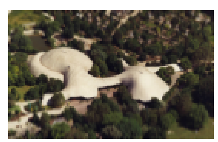


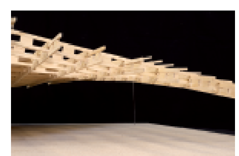


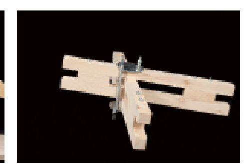
Les structures réciproques, celles de l'ingénieur Shukow, ainsi que le système Zollinger sont des structures spatiales où l'interaction entre la géométrie de l'ensemble et celle du nœud joue un rôle significatif pour la génération de la forme globale de l'ouvrage.

Coques nervurées


The Savill , Glenn Howells Architects, 2006.

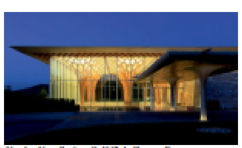

Multihalle de Manheim, Frei Otto, 1975.





Savill gardens à Windsor en Angleterre et la Multihalle à Mannheim en Allemagne sont des structures spatiales pour lesquelles la forme et la structure sont interdépendantes. Ici, une mise en forme active a été déployée.

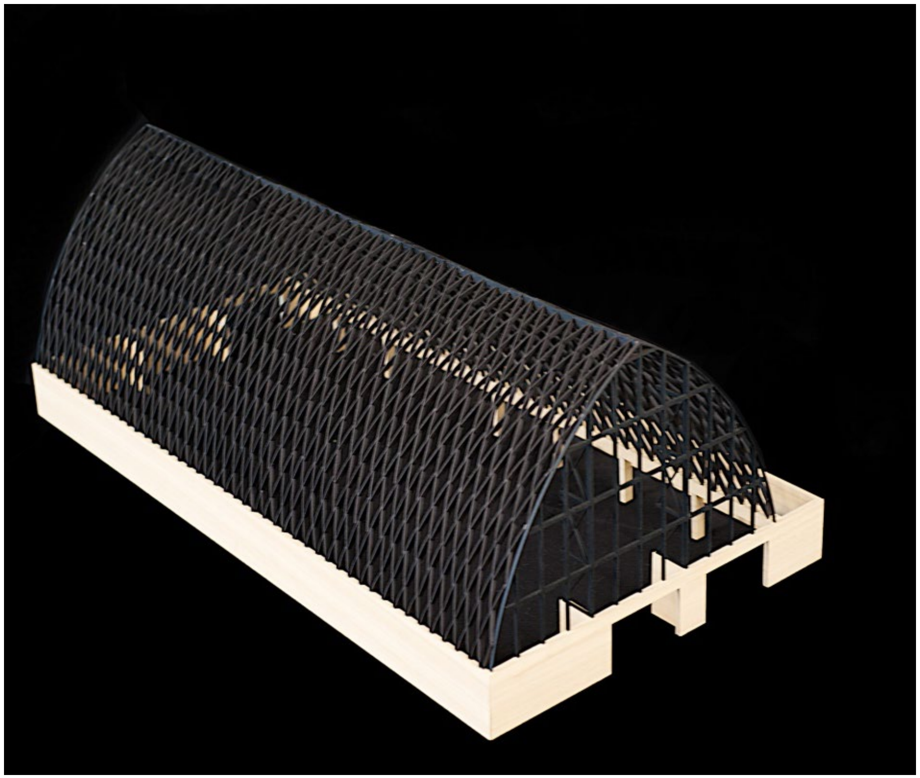
Formes libres


Haesley Nine Bridges Golf Club, Shigeru Ban, 2008.

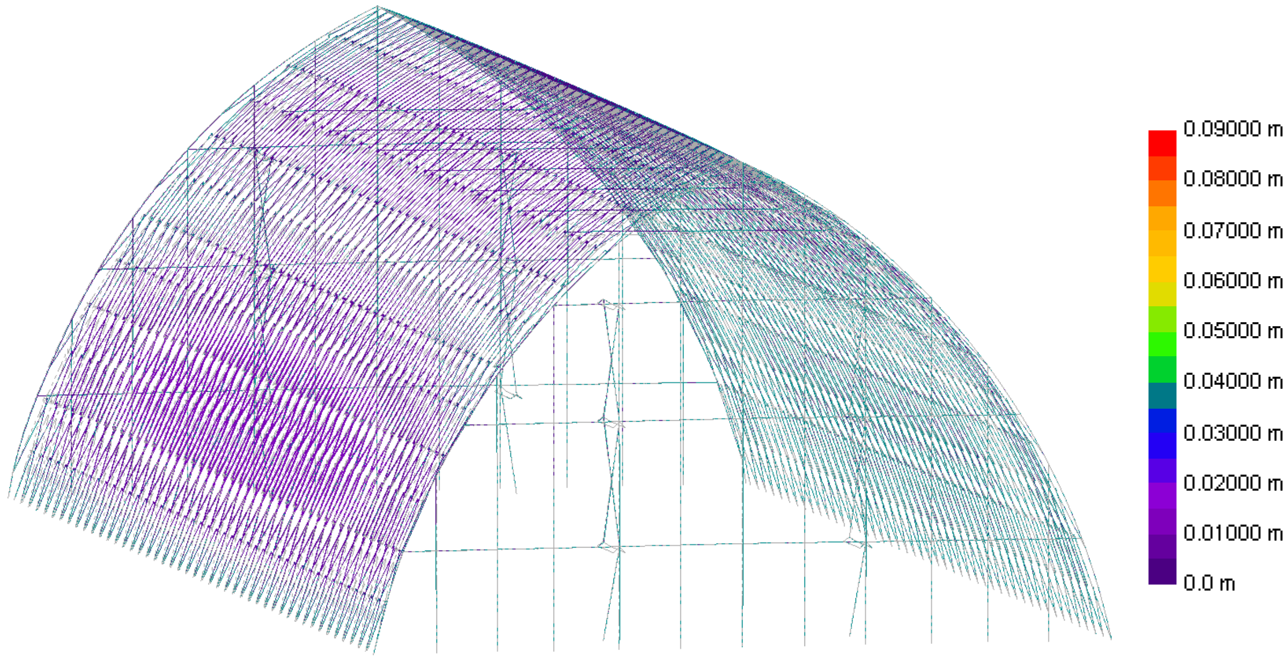

Centre pompidou Metz, Shigeru Ban, 2009.

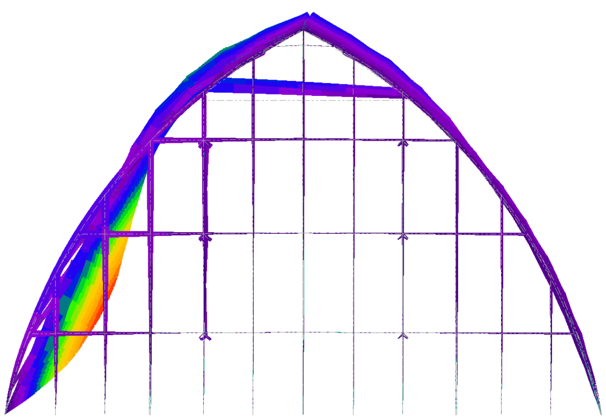
L'outil informatique permet de générer des formes quelconques. Dans le cas des structures du centre Pompidou à Metz et de celles du Golfclub en Corée du Sud dessinées par l'architecte Shigeru Ban, la fabrication de pièces découpées sur mesure s'est avérée nécessaire. Ces derniers éléments porteurs sont façonnés après l'achèvement de l'opération de la mise en forme.

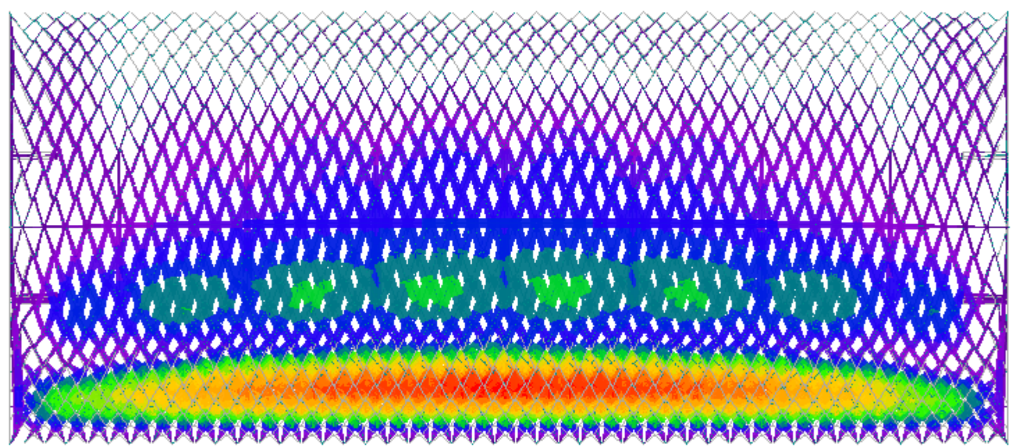
Gut Garkau, Zollinger System,1926.



Cas de charge 4 : Vent Transversal - ELS







Déformation sous l'action Vent Transversal - ELS

Teaching

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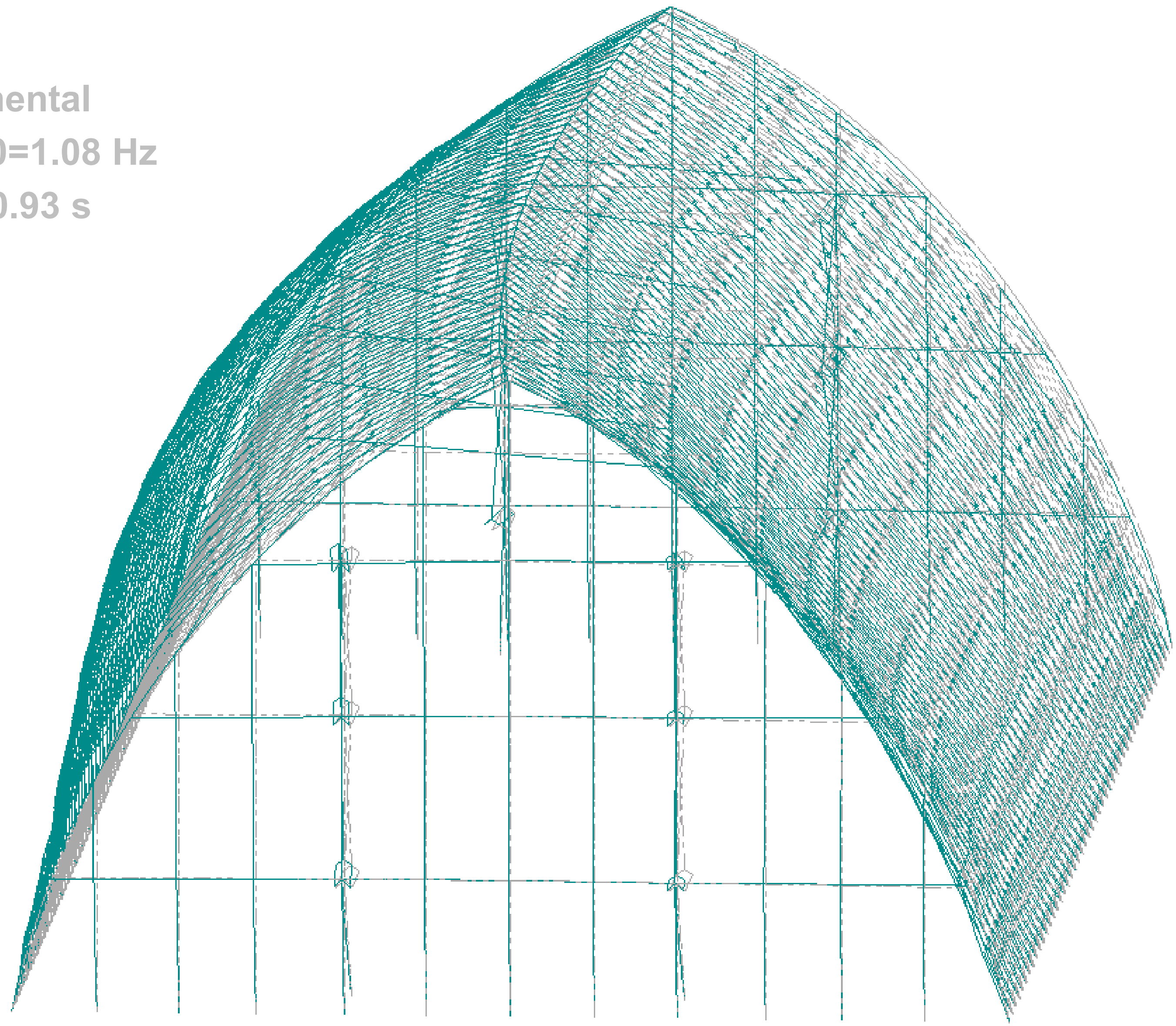
Analyse modale

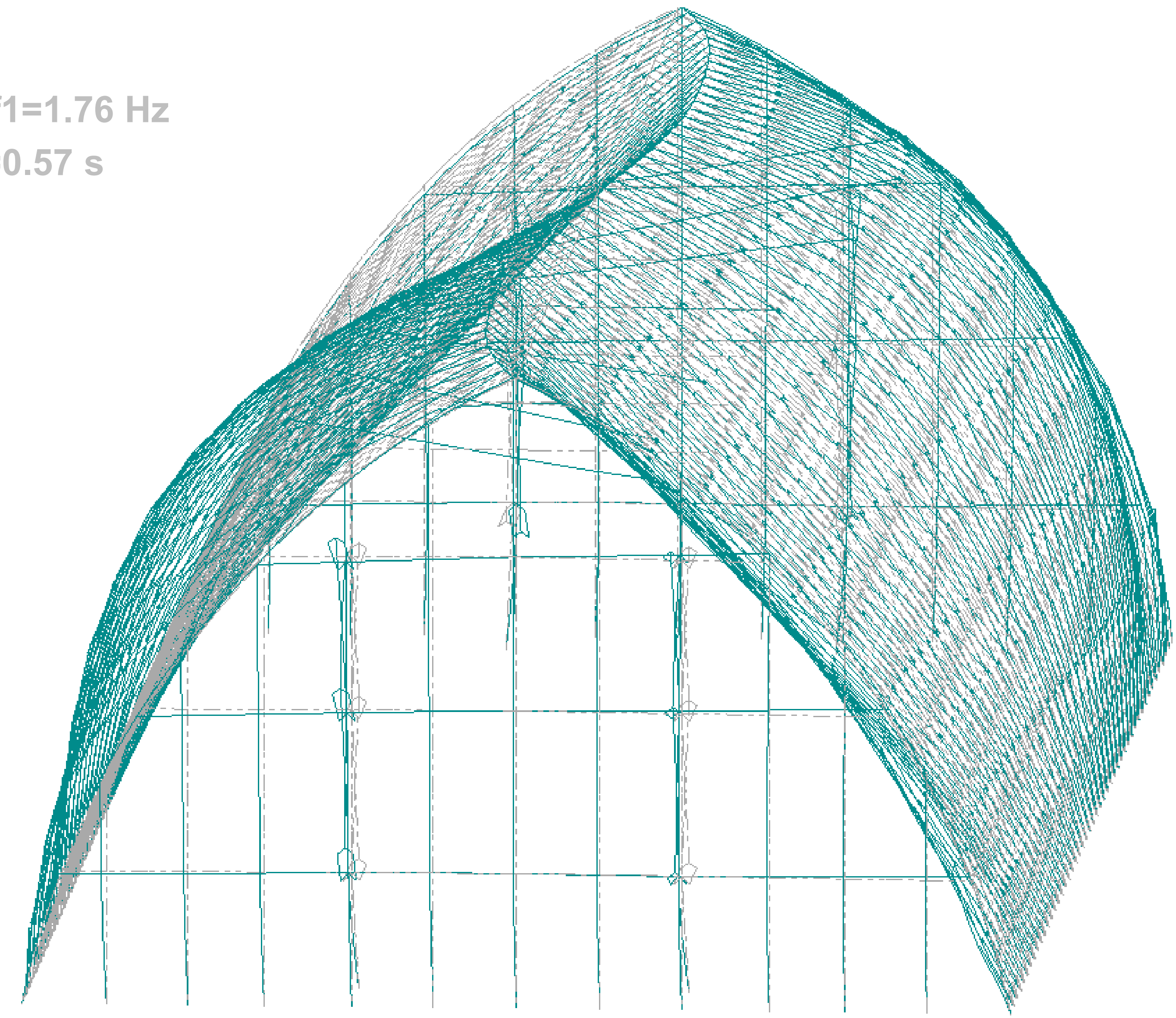
- Mode Propre 0 :
  - Mode Fondamental
  - Fréquence : f0=1.08 Hz
  - Période : T0=0.93 s



Animation du mode propre 0

Teaching

- Mode Propre 1 :
  - Fréquence : f1=1.76 Hz
  - Période : T1=0.57 s



Animation du mode propre 1

Professional Practice

Teaching

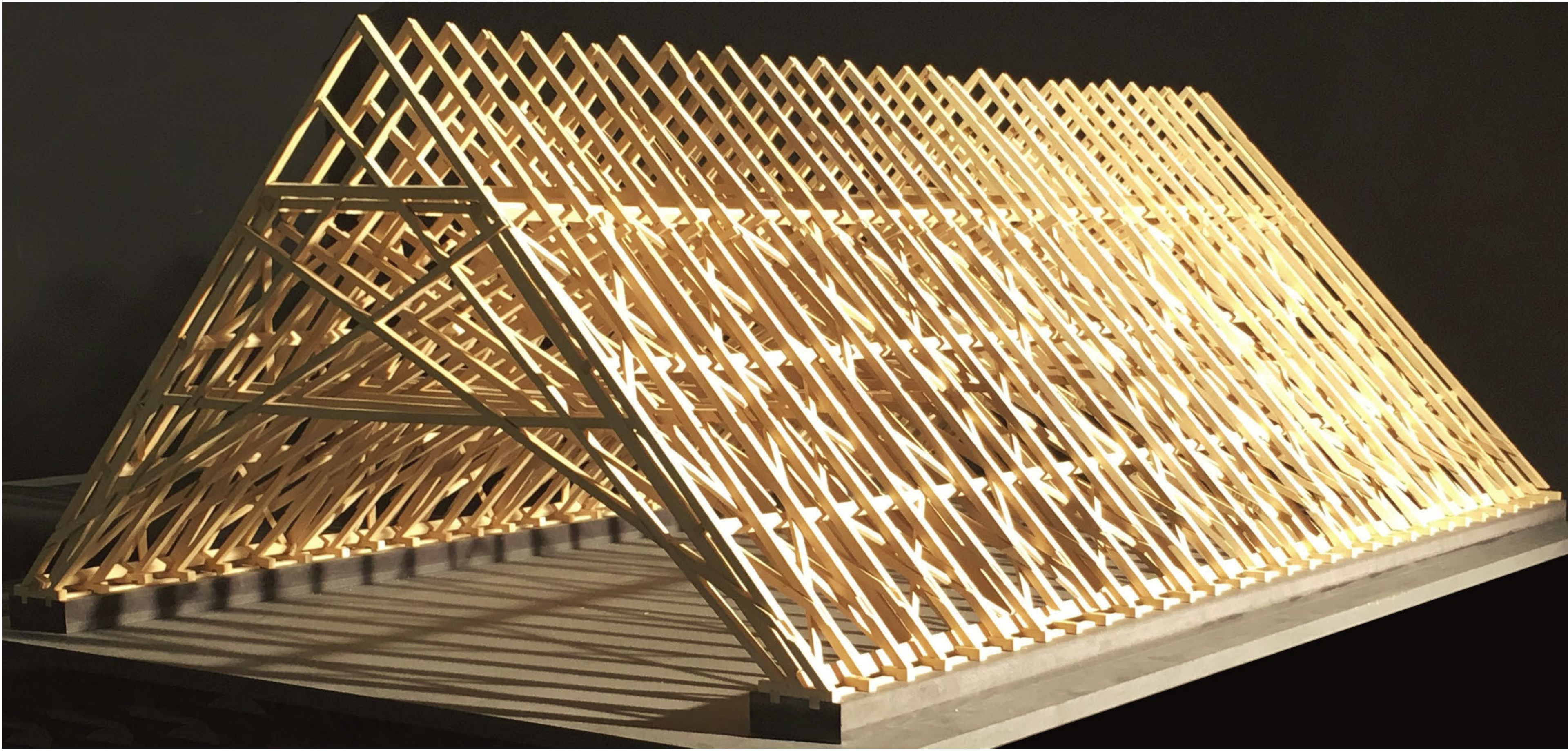
Conception des structures

Grubenmann Project

Study of a Pavilion for Vidy

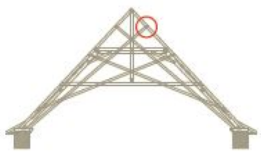
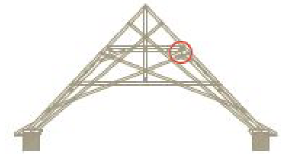
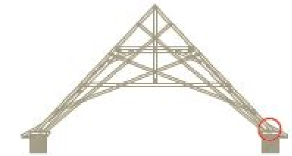
Previous Research & Completed projects

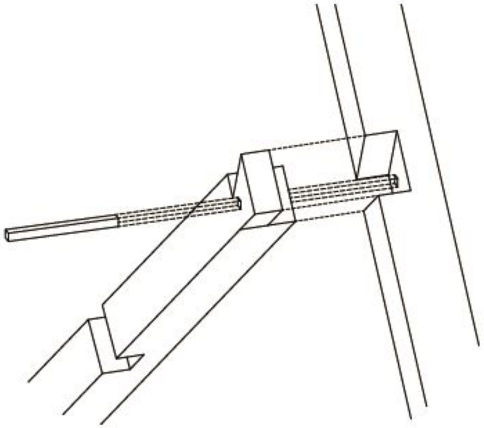
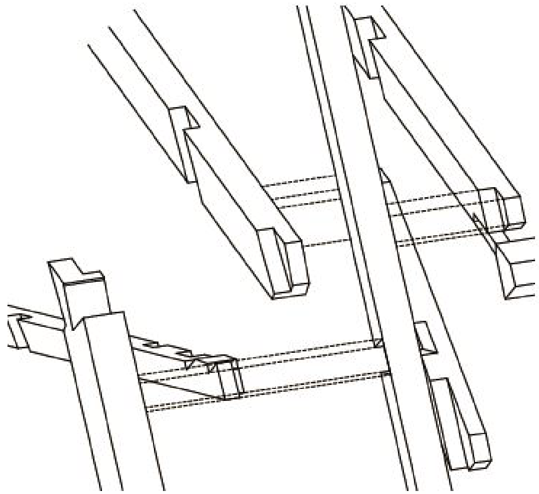
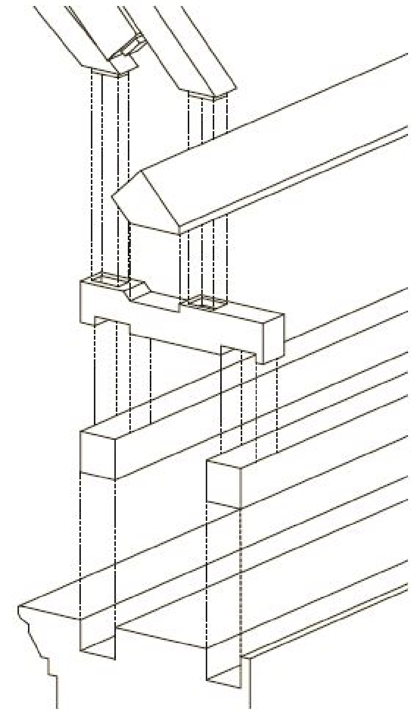
Current Research & Applied projects

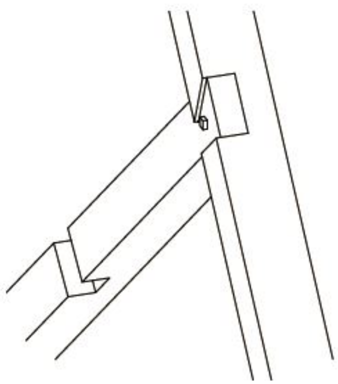
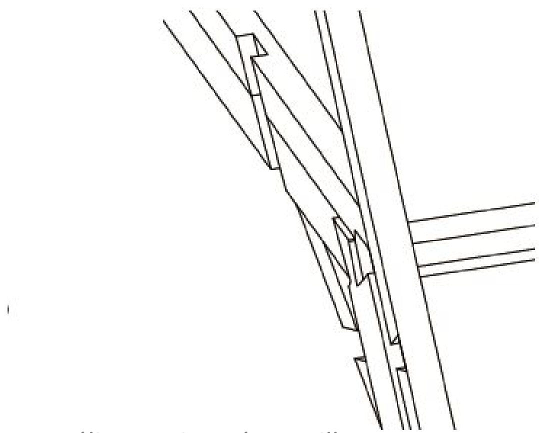
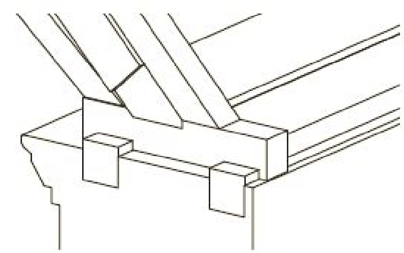


Laura Ardizzone, Joséphine Bouvet, Anthony Genton, Amélie Hautier, Léa Rouiller

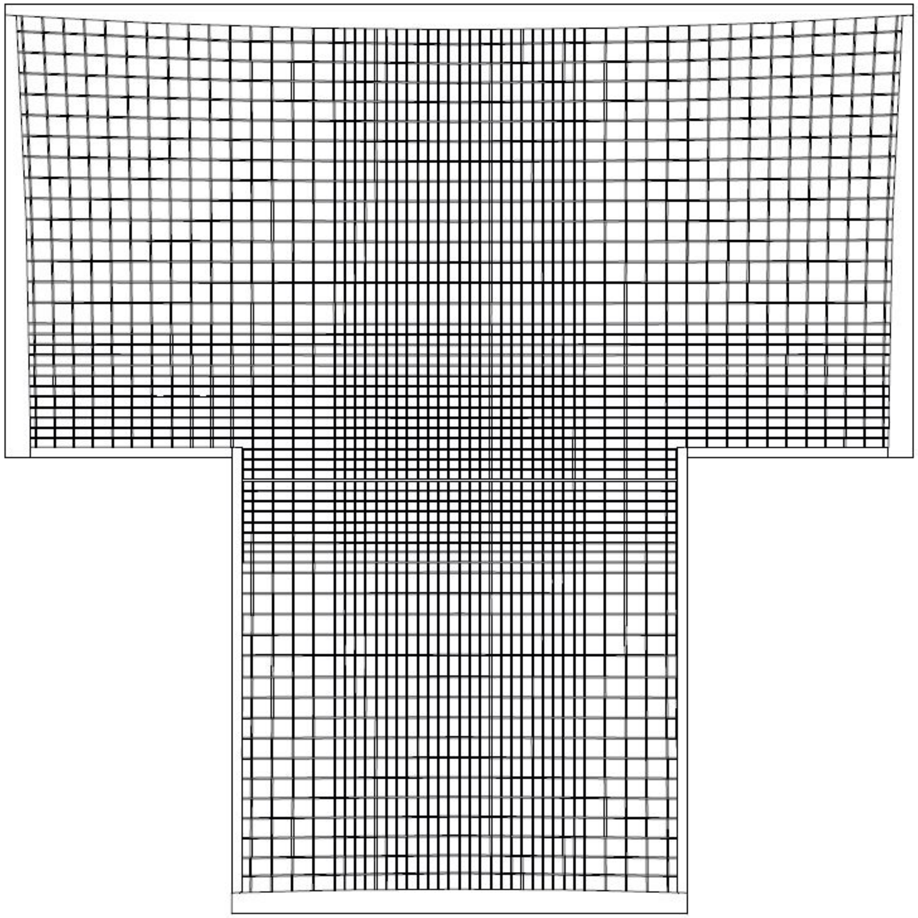
Grubenmann Project, Neuekirche Church

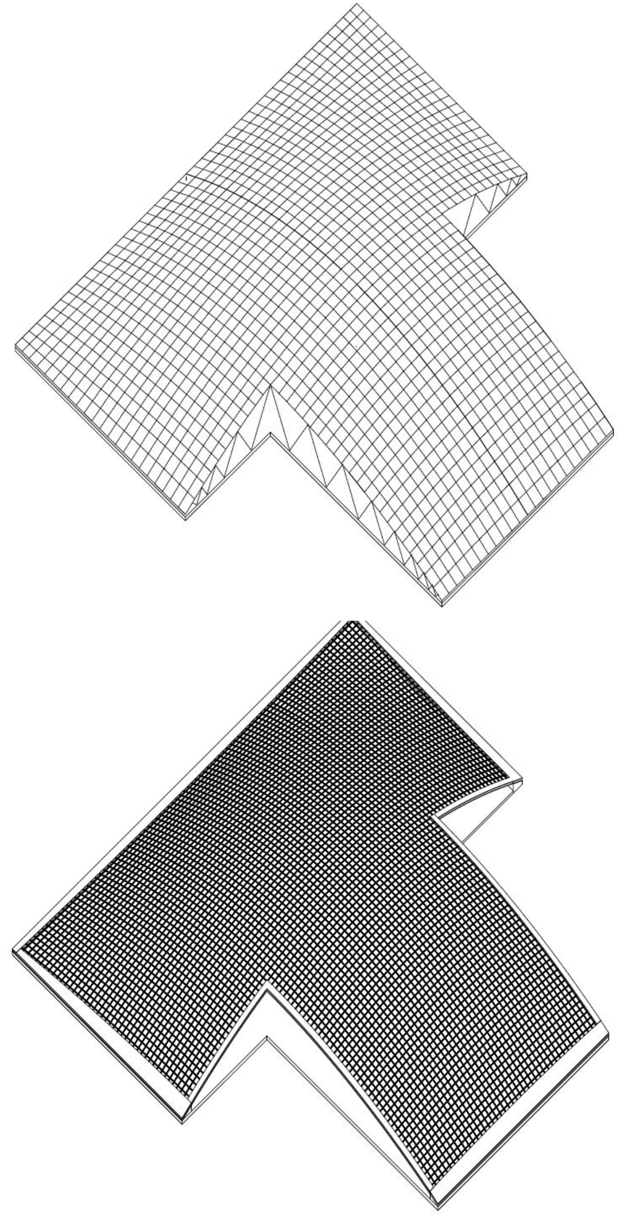




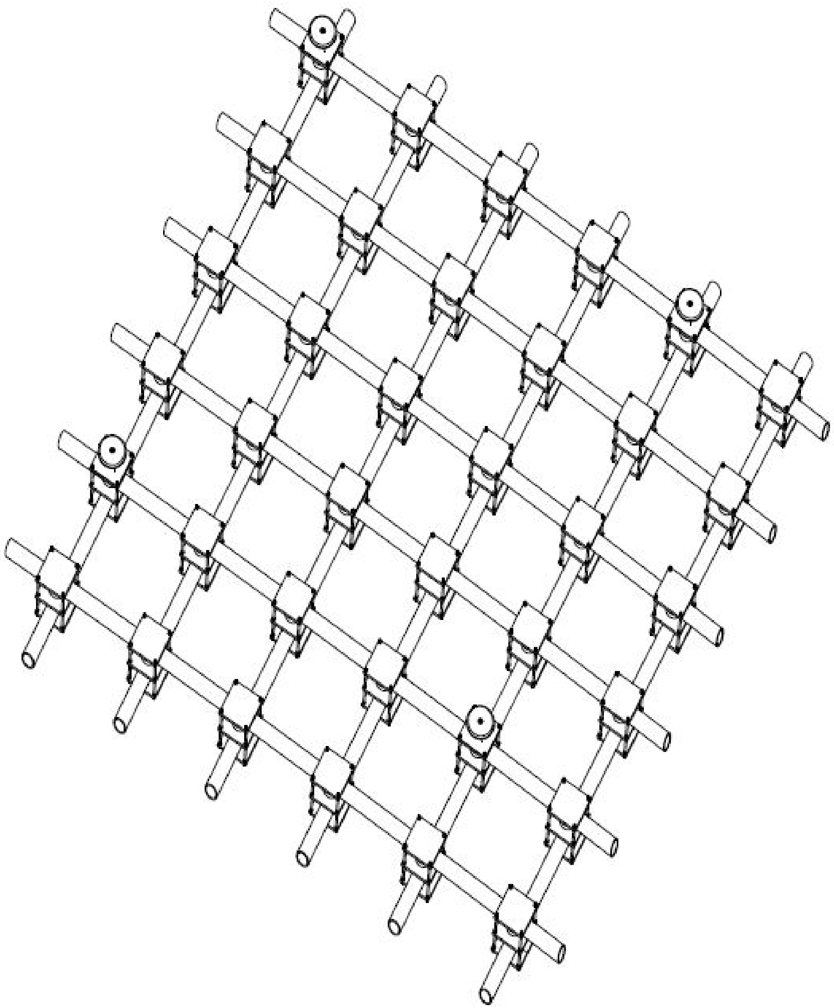




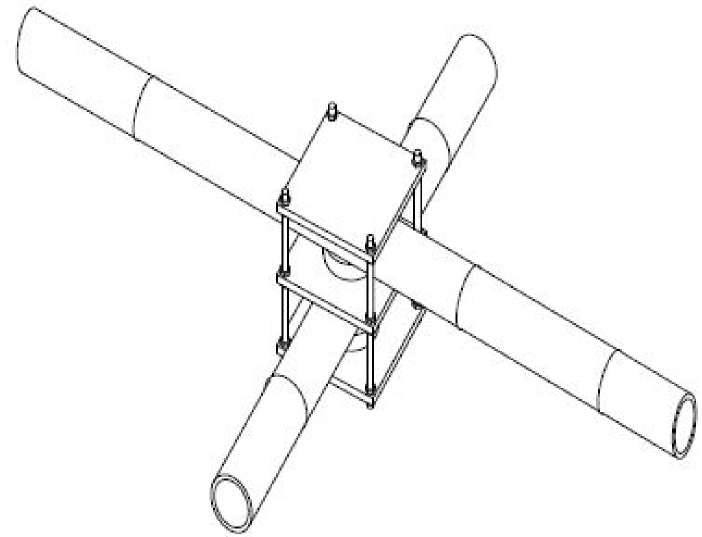
Laura Ardizzone, Joséphine Bouvet, Anthony Genton, Amélie Hautier, Léa Rouiller





Annie Bavarel, Maya Déglon, David Hoffert, Ana Villena Sandoval, Alexandre Tiarri





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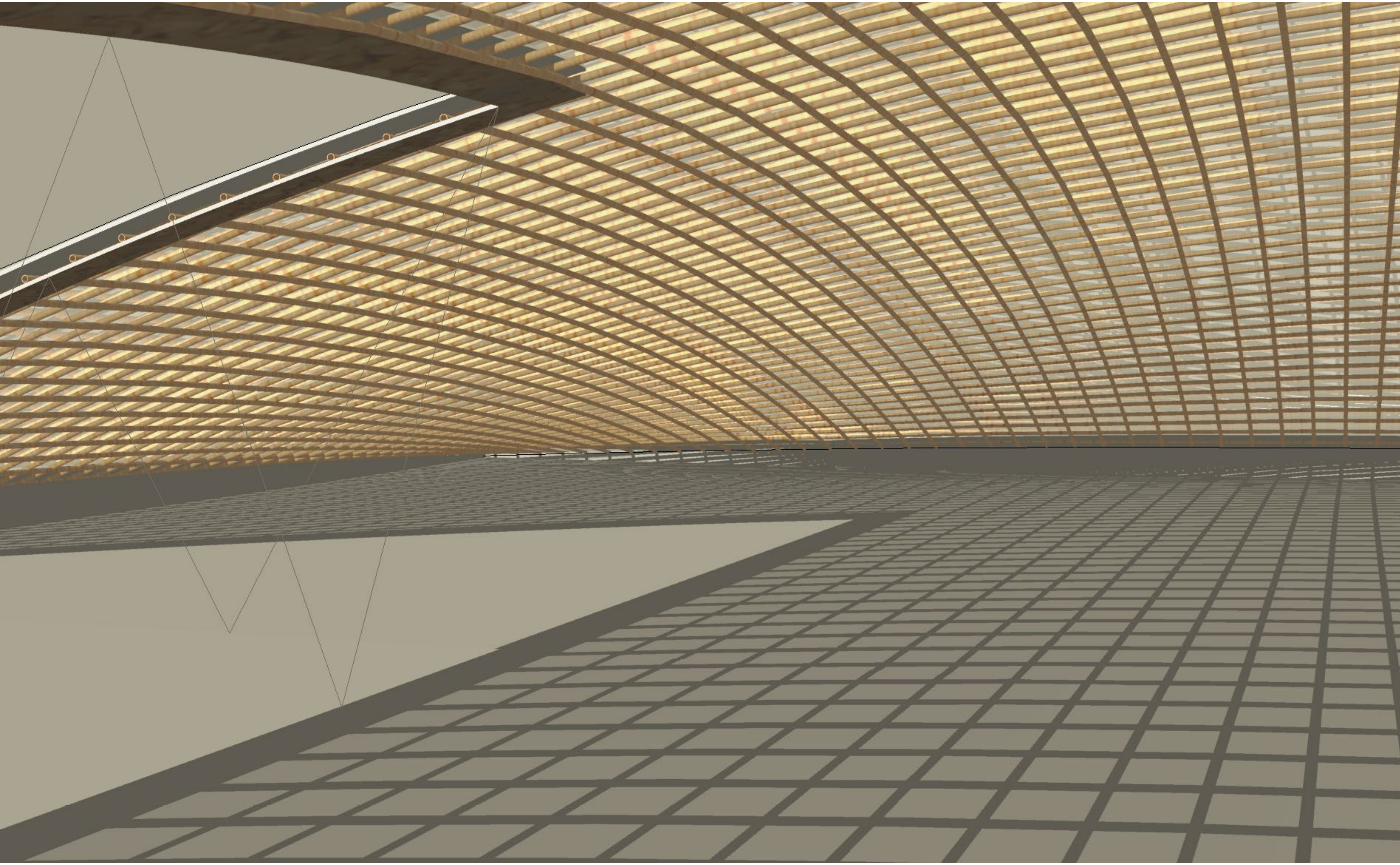
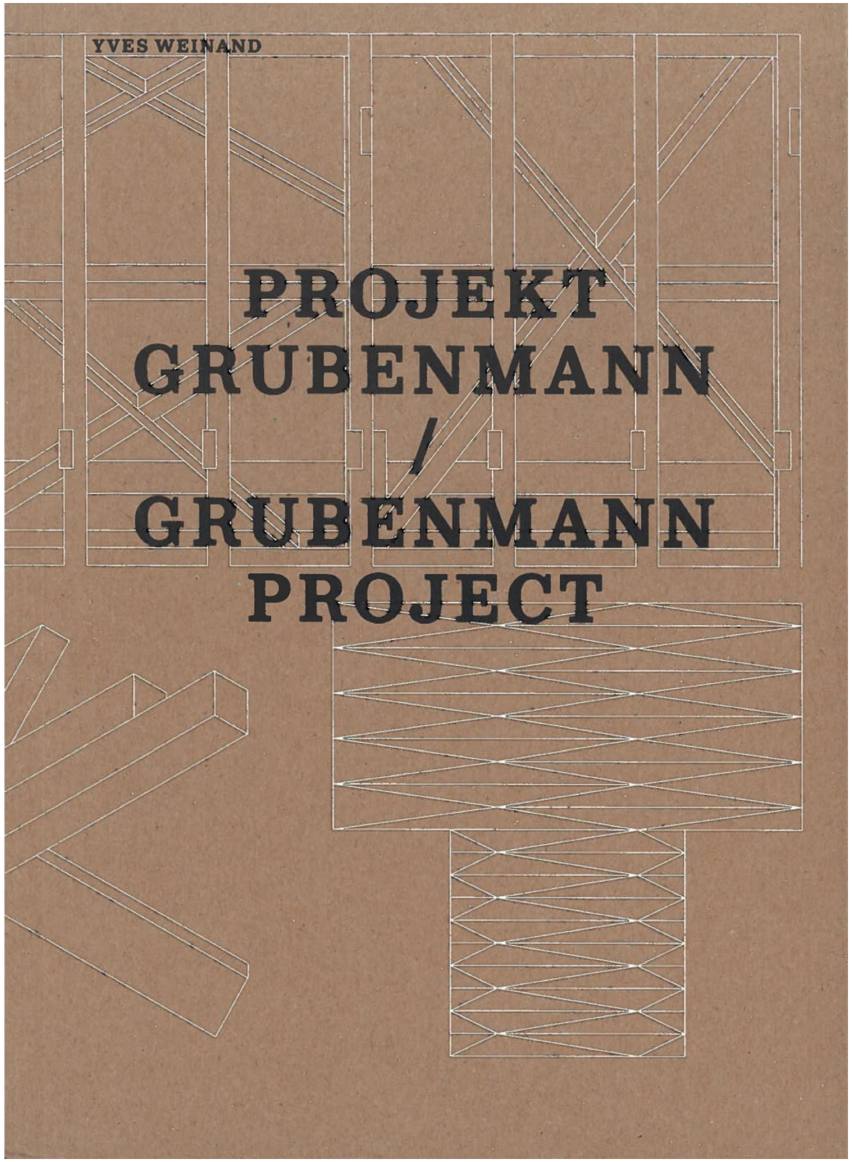
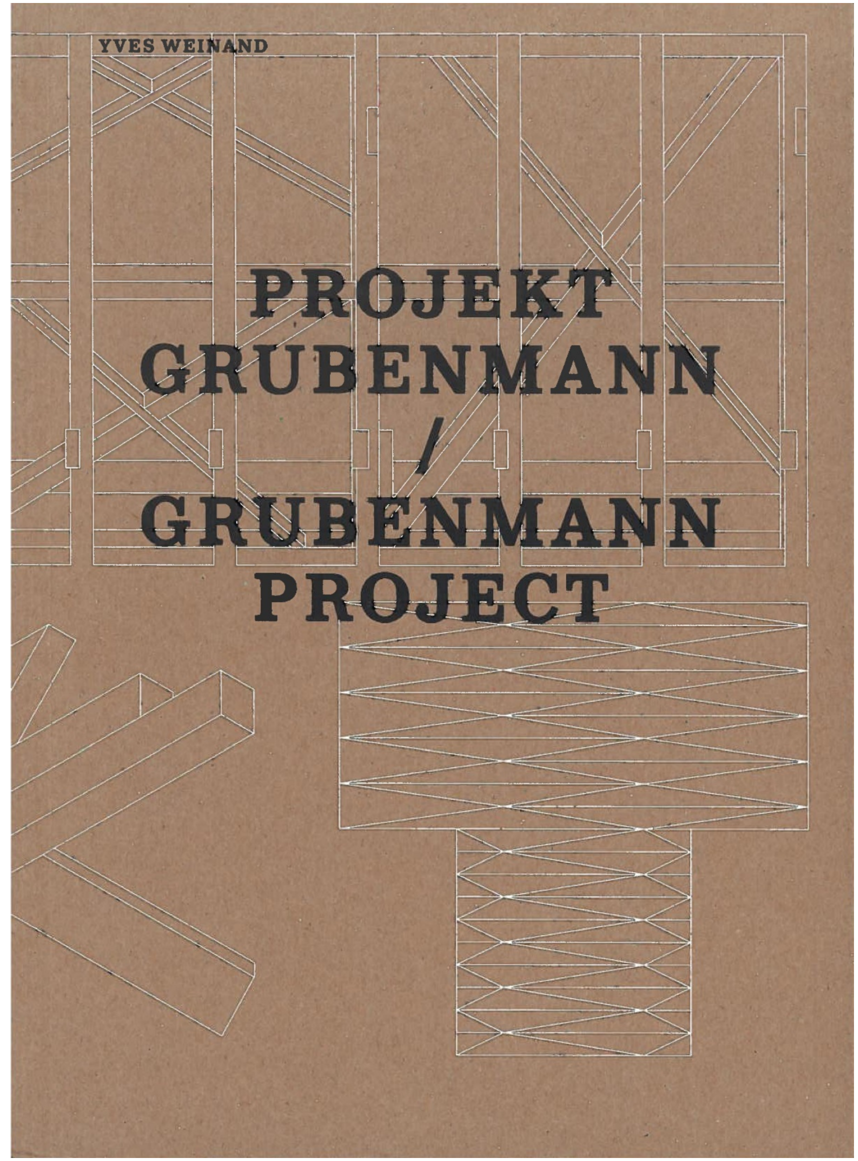


Annie Bavarel, Maya Déglon, David Hoffert, Ana Villena Sandoval, Alexandre Tiarri

Teaching

Grubenmann Project





Professional Practice

Teaching

Previous Research & Completed projects

Chapelle St Loup

Fractal geometry

Timber Fabric

Origami Beam

Modular Timber structure : Esplanade

Integral Mechanical Attachment : Mendrisio

Timber folded Structure : Vidy

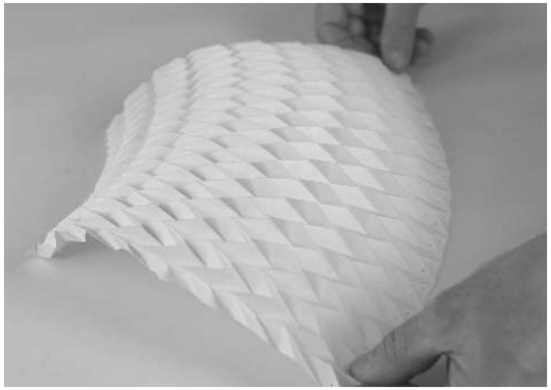
Current Research & Applied projects

Applied research

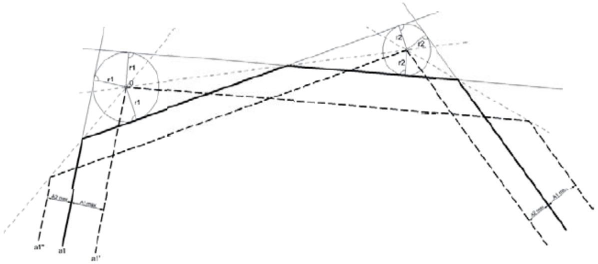
Origami – Folded Plate

An interdisciplinary reasearch between architects , engineers and mathematiciens

Folding papers

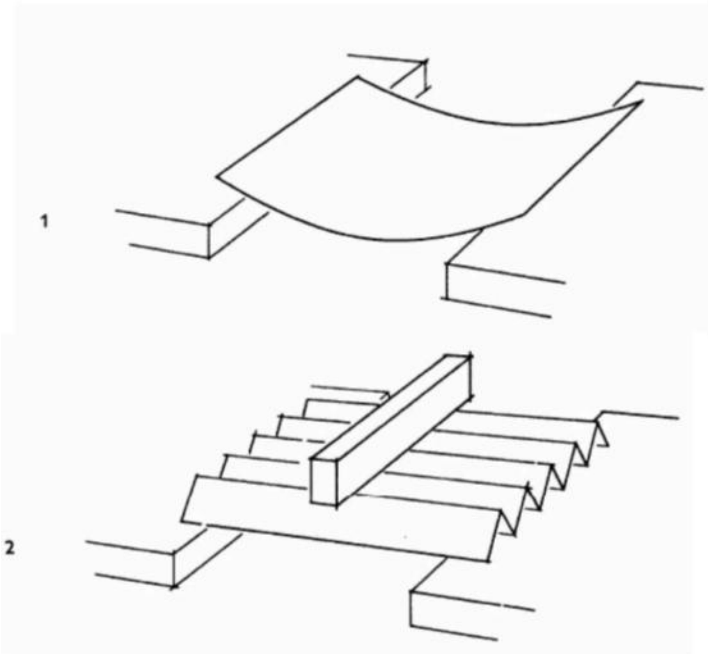


Geometry of folds



Prototypes

Hani Buri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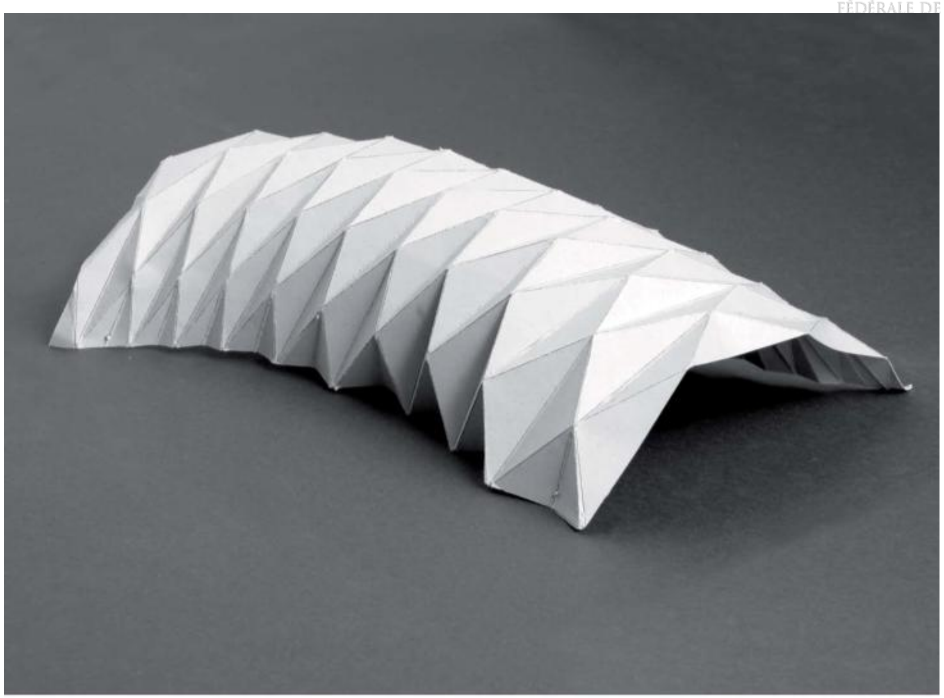
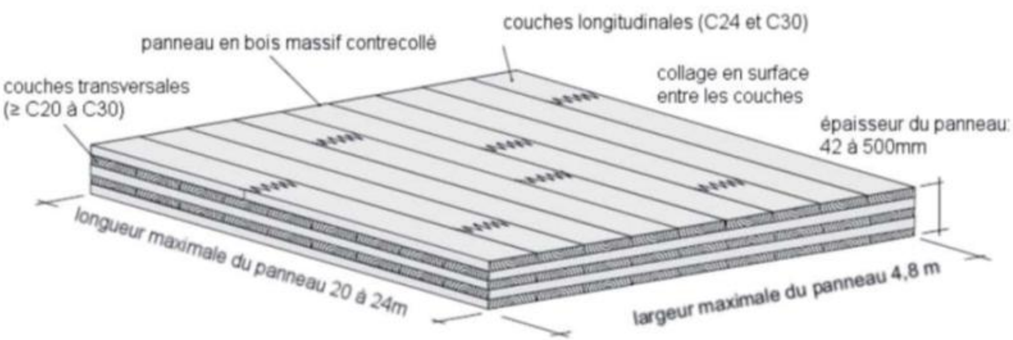
2

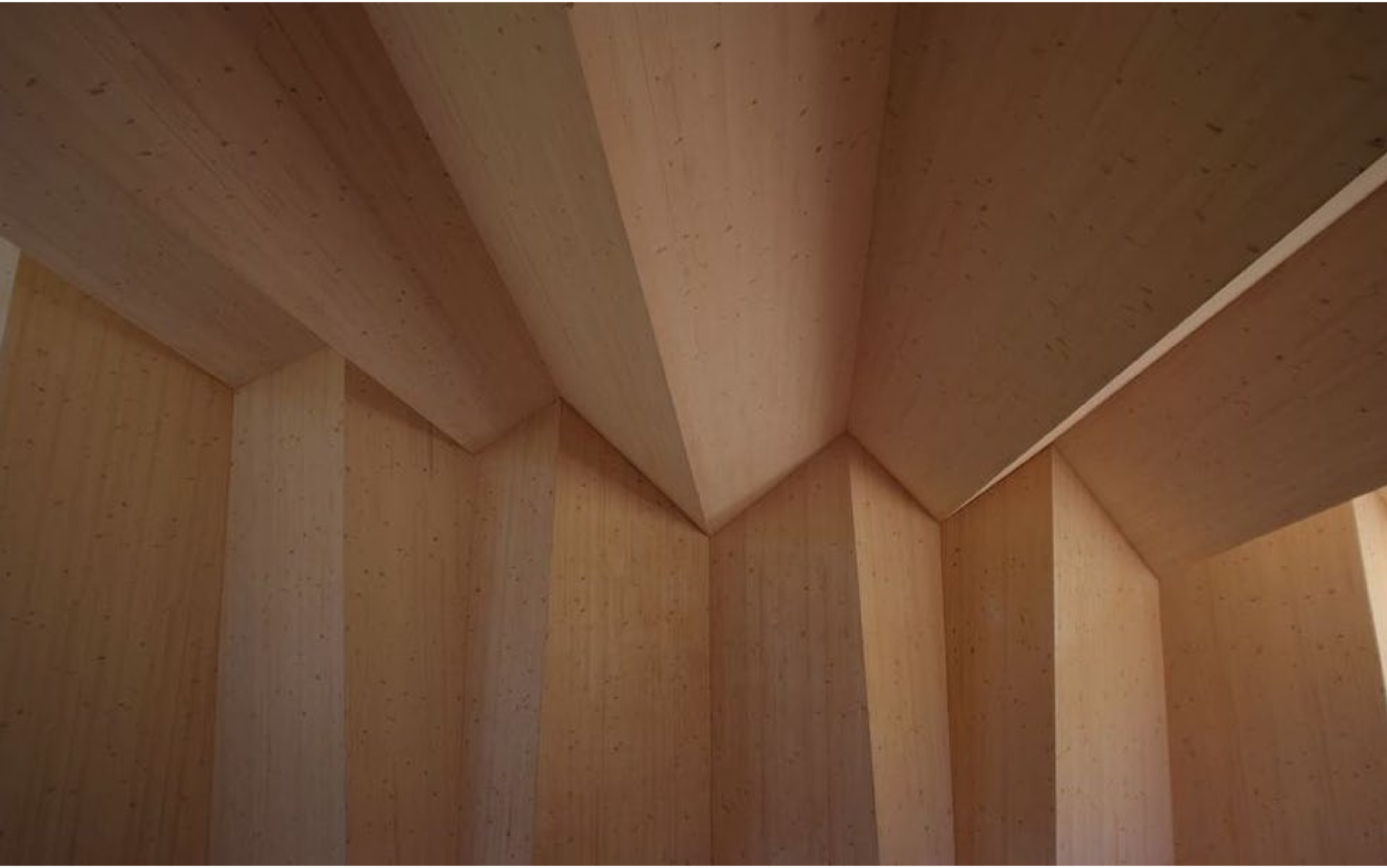



couches longitudinales (C24 et C30)
panneau en bois massif contrecollé
couches transversales
(≥ C20 à C30)
collage en surface
entre les couches
épaisseur du panneau:
42 à 500mm
longueur maximale du panneau 20 à 24m
largeur maximale du panneau 4,8 m

Montage

photo: F.Hatt

Applied research



Applied research

Applied research

Prototype: load test

Hani Buri

Professional Practice
Teaching
Previous Research & Completed projects
Chapelle St Loup
Fractal geometry
Timber Fabric
Origami Beam
Modular Timber structure : Esplanade
Integral Mechanical Attachment : Mendrisio
Timber folded Structure : Vidy
Current Research & Applied projects

Technological Evolution : Effects on Joinery (Beams)

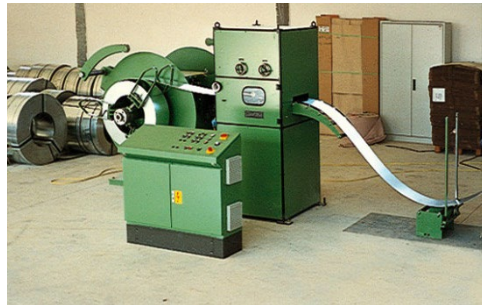
5100 B.C.: First Handcrafted Joints

Hand-Tool-Technology
Image Copyright Zimmerei Steen

Handcrafted Rafter Joints, Wood Nails

+ Variable, Custom Solutions
+ High stiffness, Rigidity
+ Fire Res., Thermal Cond.
- Laborious, Time-consuming
- rel. low precision

1750: Machine (Power) -Tools

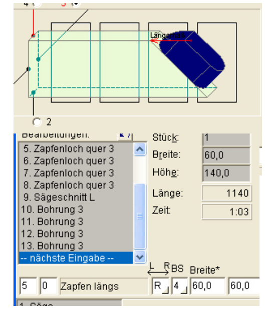


Machine-Tool-Technology
Image Copyright Wolf Systembau m.b.H.

Nail plate Connector (Metal Plates)

+ Efficient Production of Joints
+ Efficient Assembly
- Not variable, Mass Production
- Low stiffness, Rigidity
- Low precision
- Fire Res., Thermal Cond.

1989: Computer-controlled Information-Tool-Technology



K2i Automatic Joinery Machine
Image Copyright: Hans Hundegger Maschinenbau GmbH

K2i Joinery Machine Samples
Image Copyright: Hans Hundegger Maschinenbau GmbH

+ Efficient Production of Joints
+ Efficient Assembly
+ Certain Variability, Custom Solutions
+ High stiffness, Rigidity
+ High precision
+ Fire Res., Thermal Cond.

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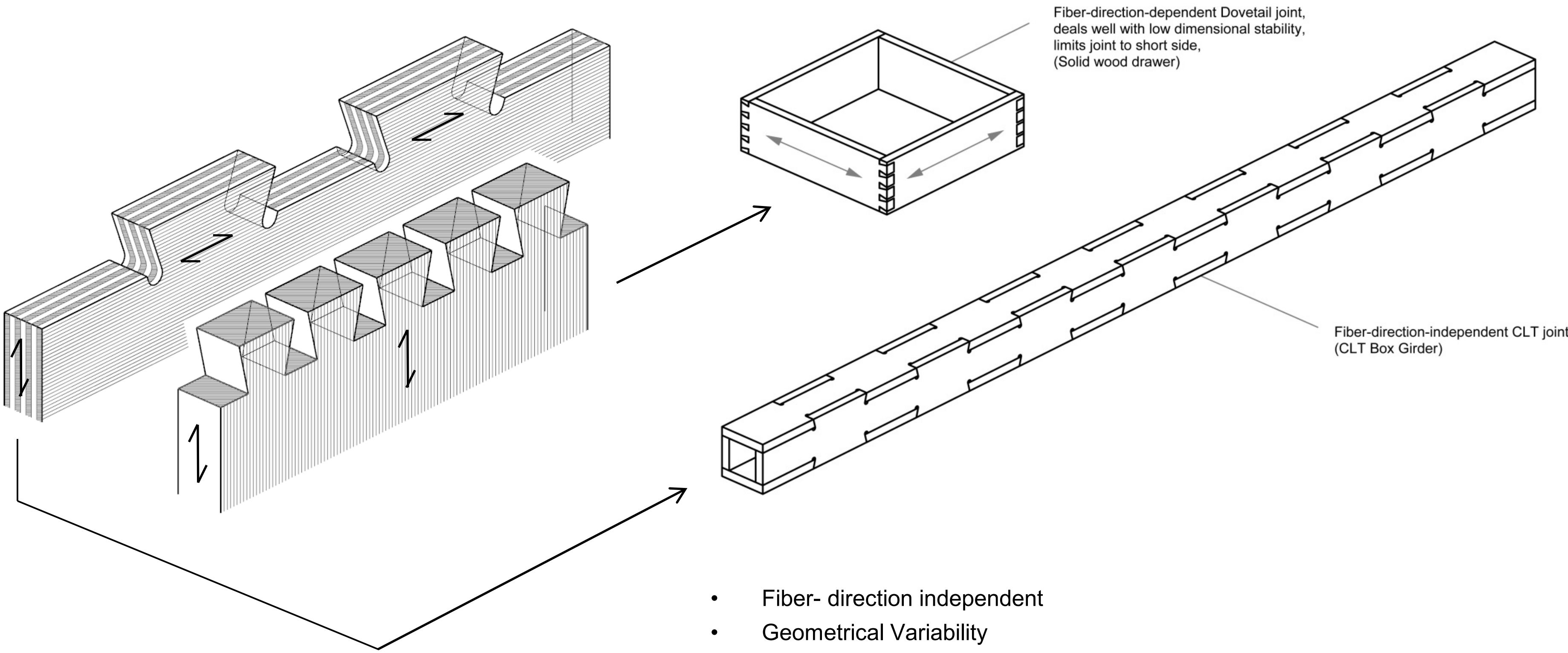
New Applications with cross-laminated panels + CNC



- Fiber- direction independent
- Geometrical Variability
- CNC Technology allows for fast, precise and cost-efficient automatic production
- Larger inclination possible, stronger joint

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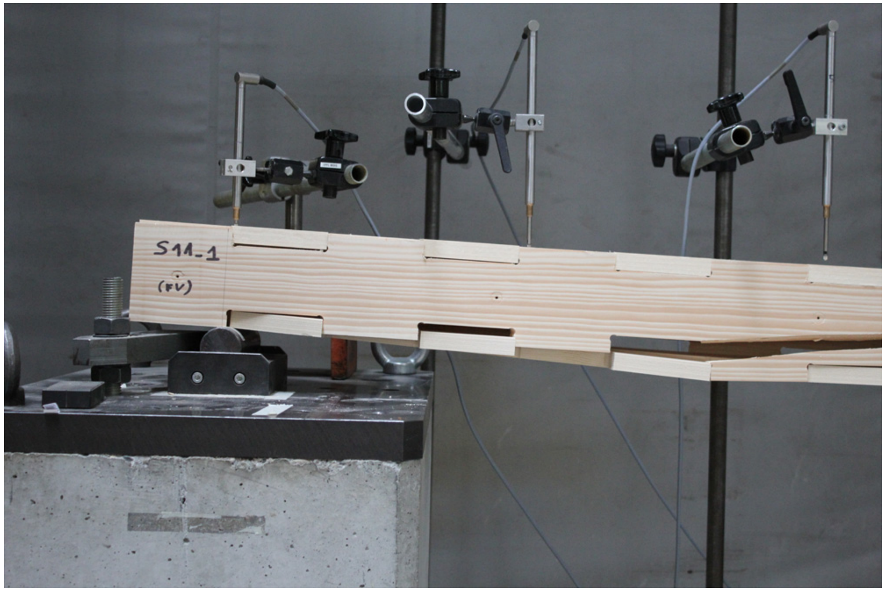
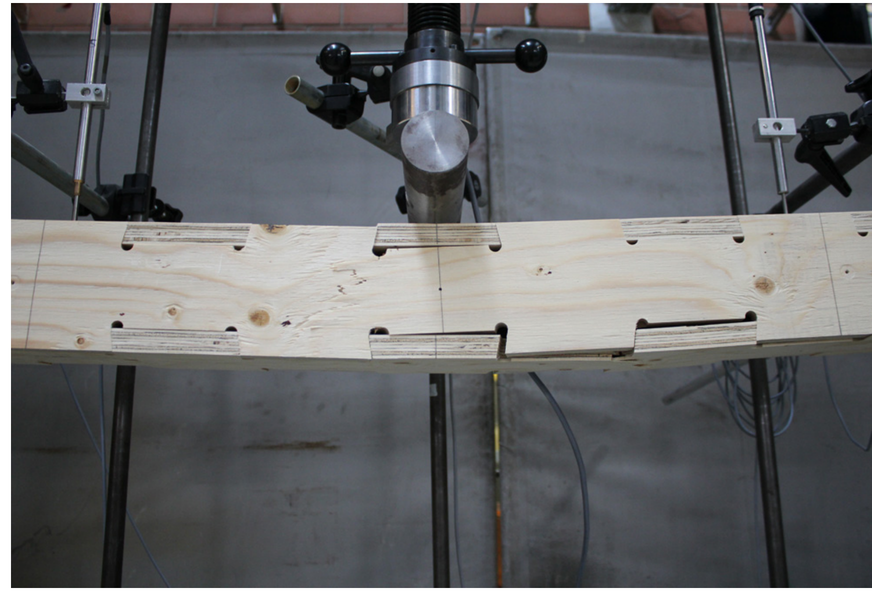
Parameter / Material Experiments

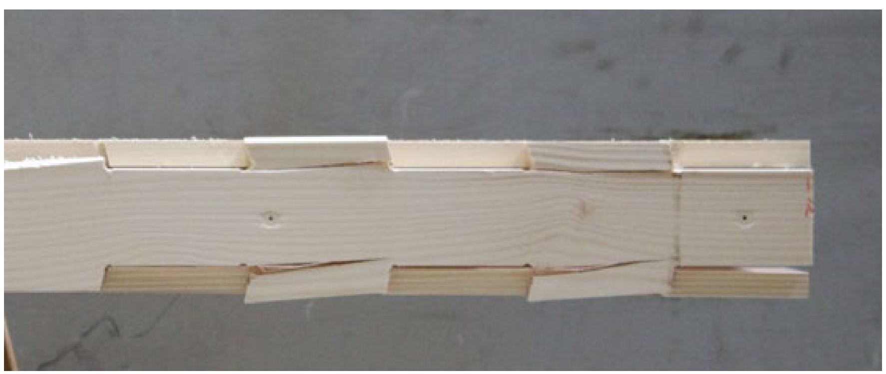
Spruce (solid wood)



Spruce (cross-laminated)



Shear failure in the connection



Failure in the panel

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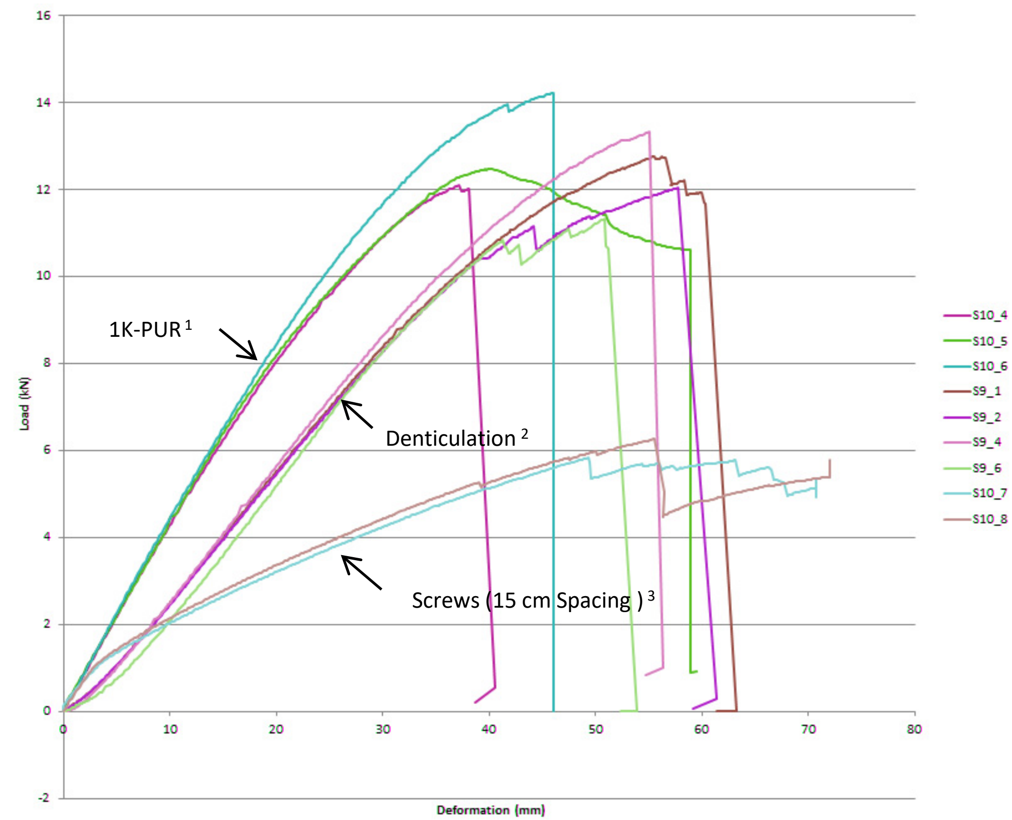
Comparison of edge-connections for cross-laminated panels (KERTO-Q)

Box Girder Parameter Study: Specimen Geometry and Parameters — Material Parameters — Specimen Parameters — Experiment: 3-point flexural test

Specim	Manufact	Product	Species	t_{ref}	t_{eff}	m	n	s	l	w	h	d	l/d	Type	r_{notch}	α	±α	Remarks	Date	F_{max} (kN)	$δ_1$ (5kN)	$δ_{max}$ (mm)	Ø F_{max} (kN)	Ø δ1 (5kN)
	Schilliger	CLT	Spruce	19	19.1	3	1	2000	2200	90	90	14	146.66	screw	3.77	15°	a							
	Schilliger	CLT	Spruce	19	19.1	3	1	2000	2200	90	90	14	146.66	A	3.77	15°	a							
	Schilliger	CLT	Spruce	19	19.1	3	1	2000	2200	90	90	14	146.66	A	6	15°	a							
	Schilliger	CLT	Spruce	19	19.1	3	1	2000	2200	90	90	31	70.967742	A	3.77	15°	a							
	Schilliger	CLT	Spruce	19	19.1	3	1	2000	2200	90	90	31	70.967742	A	6	15°	a							
S5_1	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	3.77	15°	b	small notch	Mrz 13	10.241	17.76	41.55		
S5_2	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	3.77	15°	b	small notch	20.03.2013	11.878	19.92	50.88	11.0595	18.84
S6_1	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b		Mrz 13	9.512	19.26	39.76		
S6_2	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b		Mrz 13	8.987	20.33	35.3	9.5676667	19.103333
S6_3	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b		Mrz 13	10.204	17.72	37.35		
S7_1	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	A	5.801	15°	b	Parallel	Mrz 13	10.78	19.51	46.45		
S7_2	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	A	5.801	15°	b	Parallel	Mrz 13	10.957	18.59	45.65	11.287	18.64
S7_3	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	A	5.801	15°	b	Parallel	Mrz 13	12.124	17.82	51.9		
S8_1	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	149	99.5	21	115.78947	B	5.801	15°	b	w +50mm	Mrz 13	16.1	13.68	56.35		
S8_2	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	149	99.5	21	115.78947	B	5.801	15°	b	w +50mm	20.03.2013	12.302	15.77	40.26	14.470667	14.69
S8_3	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	149	99.5	21	115.78947	B	5.801	15°	b	w +50mm	20.03.2013	15.01	14.62	66.71		
S9_1	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b	tan. notch	20.03.2013	12.209	18.33	58.32		
S9_2	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b	tan. notch	20.03.2013	12.034	18.45	57.76		
S9_3	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b	tan. notch	20.03.2013	9.248	19.21	39.16		
S9_4	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b	tan. notch	22.03.2013	13.322	17.98	55.02	11.525143	18.47
S9_5	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b	tan. notch	03.04.2013	11.528	18.66	64.95		
S9_6	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b	tan. notch	11.04.2013	11.33	19.47	50.86		
S9_7	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5	21	115.78947	B	5.801	15°	b	tan. notch	11..04.2013	11.005	17.19	45.86		
S10_1	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5							1K-PUR, Vert.	11.04.2013	14.136	11.58	35.49		
S10_2	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5							1K-PUR, Vert.	11.04.2013	15.354	10.95	38.83	14.889667	10.886667
S10_3	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5							1K-PUR, Vert.	11.04.2013	15.179	10.13	37.31		
S10_4	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5							1K-PUR, Hor.	16.04.2013	12.024	11.88	38.16		
S10_5	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5							1K-PUR, Hor.	16.04.2013	12.464	11.71	39.6	12.896667	11.663333
S10_6	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5							1K-PUR, Hor.	16.04.2013	14.202	11.4	46.01		
S10_7	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5							37x Assys 4x40 26	16.04.2013	5.332	38.37	70.76	5.477	37.22
S10_8	Metsä W	Kerto Q	Spruce	21	21	7	2	2211	2431.6	99.5	99.5							37x Assys 4x40 26	16.04.2013	5.622	36.07	72.08		

3-point bending test



3-point bending test

[1] 1K-PUR Adhesive Colano Semparoc Rapid S (S10_4, S10_5, S10_6)

[2] Denticulation, Joint Length 115mm (S9_1, S9_2, S9_4, S9_6)

[3] 37 pcs. Würth Assys 3 x 40 26 self-tapping, perpendicular (S10_7, S10_8)

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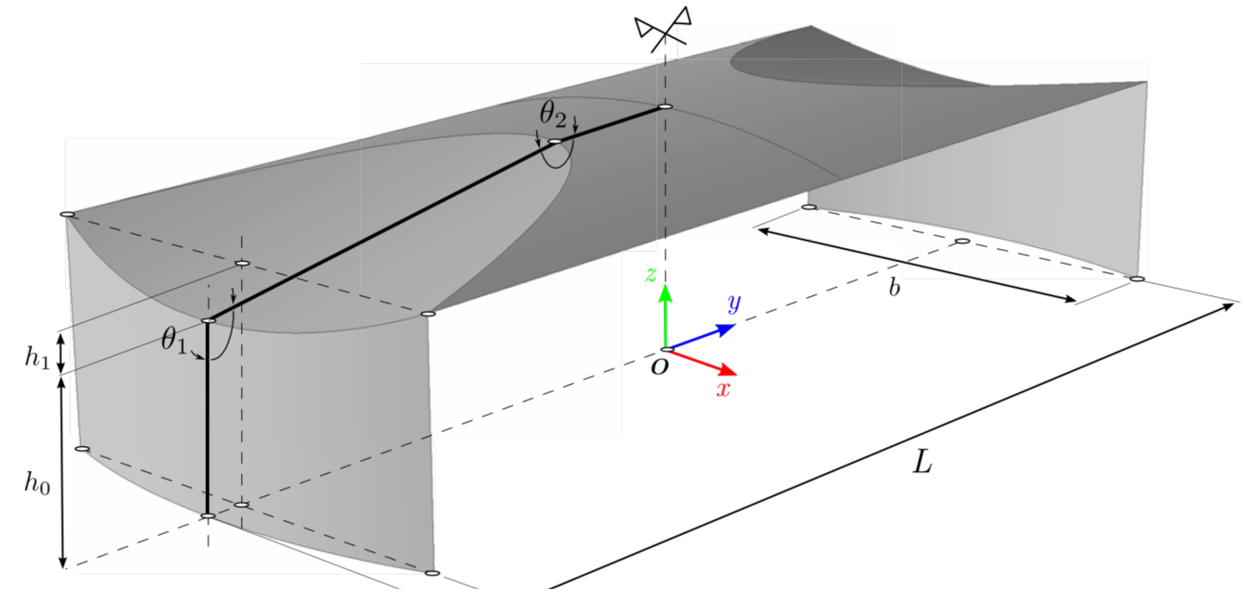
Wood/wood connection: Dovetails blocking 5-degrees of displacement

Parameter Studies:
Panel Thickness, Number and spacing of dents, Angle of the dovetail, Amount of cut over

Christopher Robeller, Laurent Humber, Yves Weinand

Origami Pavillion



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Assembly (1:5 Prototype)

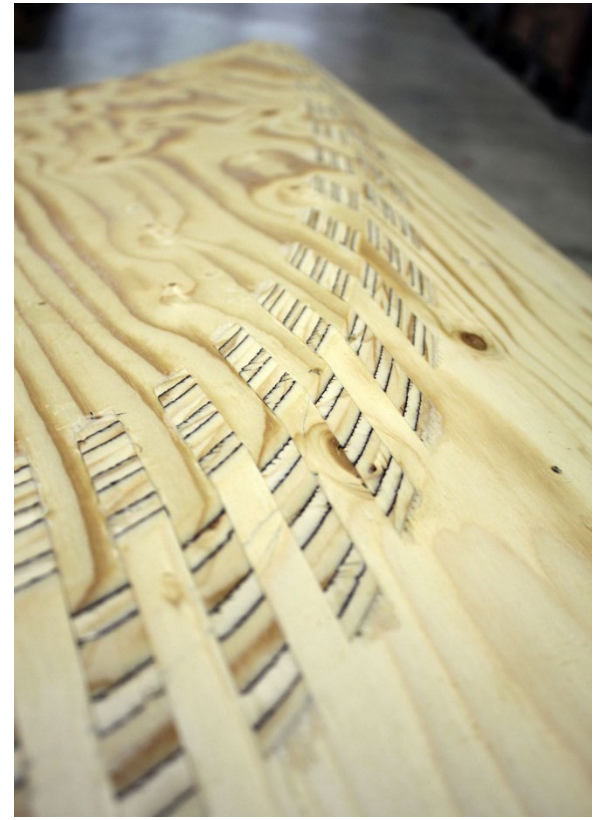
Jointed Roof Elements

Dovetail Joints fit precisely

Christopher Robeller, Laurent Humber, Yves Weinand

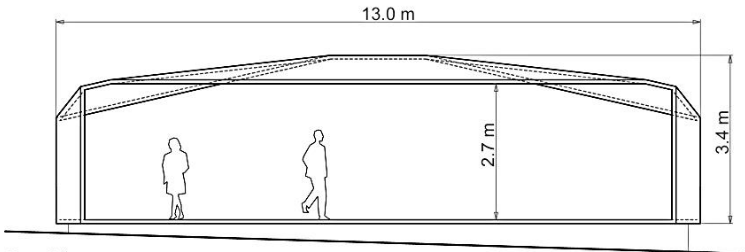
Complete 1:5 Prototype

Complete Prototype at Scale 1:5

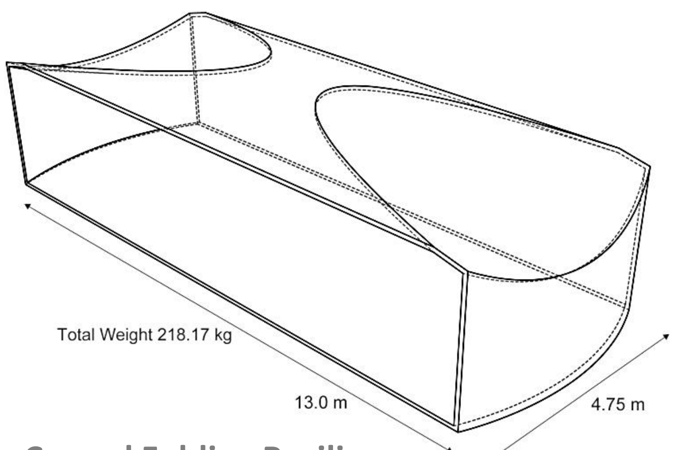


Assembly of the two halves of the structure

Connection of curved CLT panels (LENO)



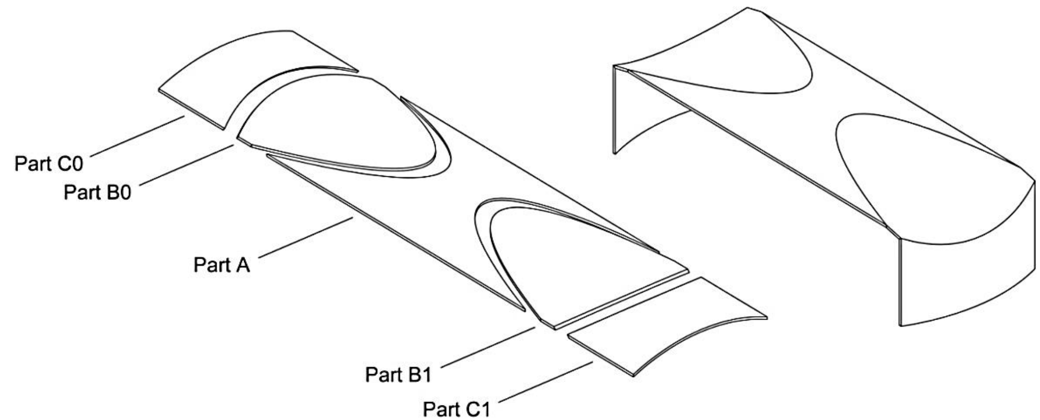
Front View



Curved Folding Pavilion
Concept and Dimensions

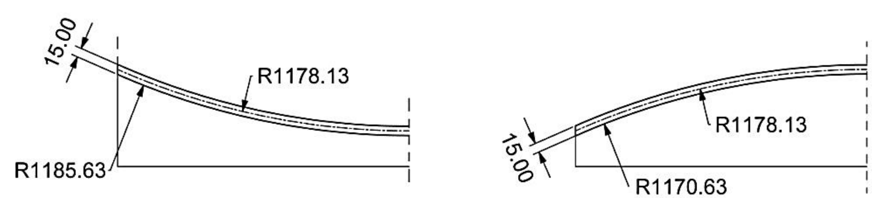
R Outside	1185.63
R Midsurface	1178.13
R Inside	1170.63

Prototype Scale	1:5
Material	15mm CLT
Layers	3 x 5mm, 7L, Spruce

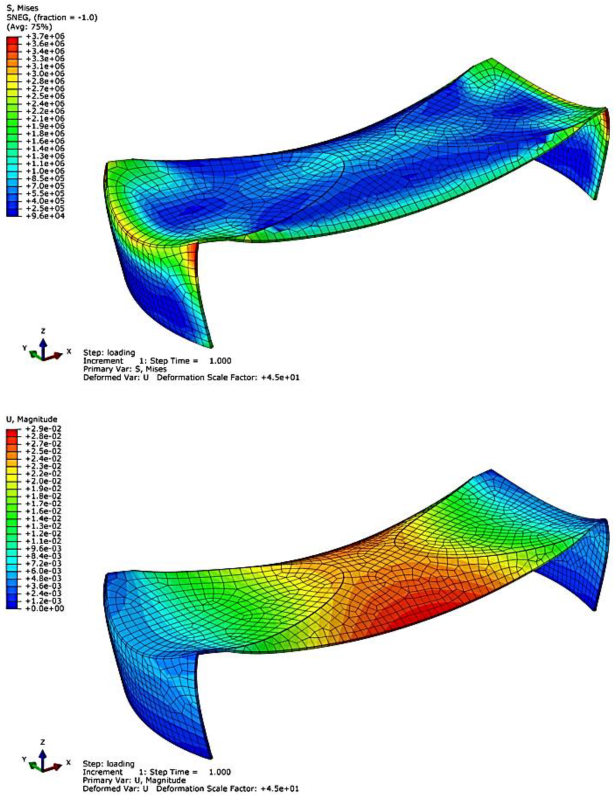


Mold 2 / Concave
R=1185.63

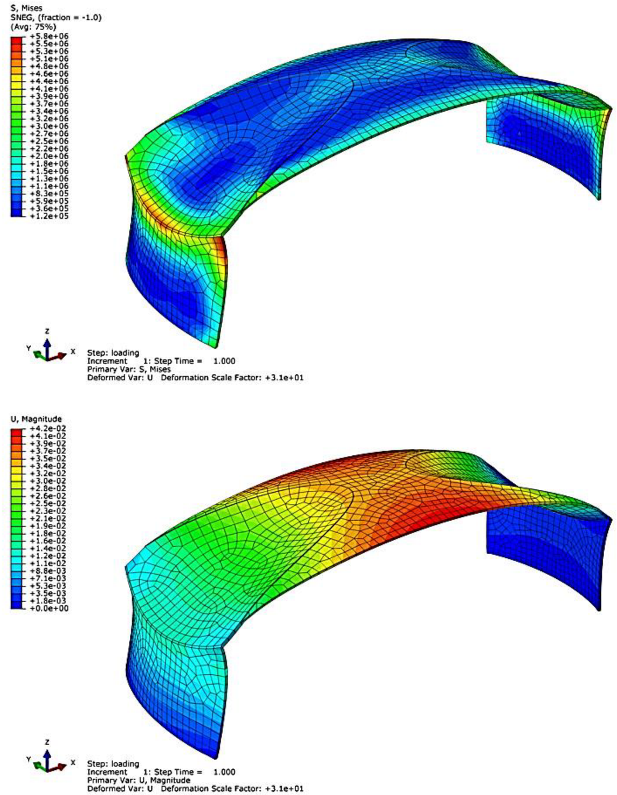
Mold 1 / Convex
R=1170.63



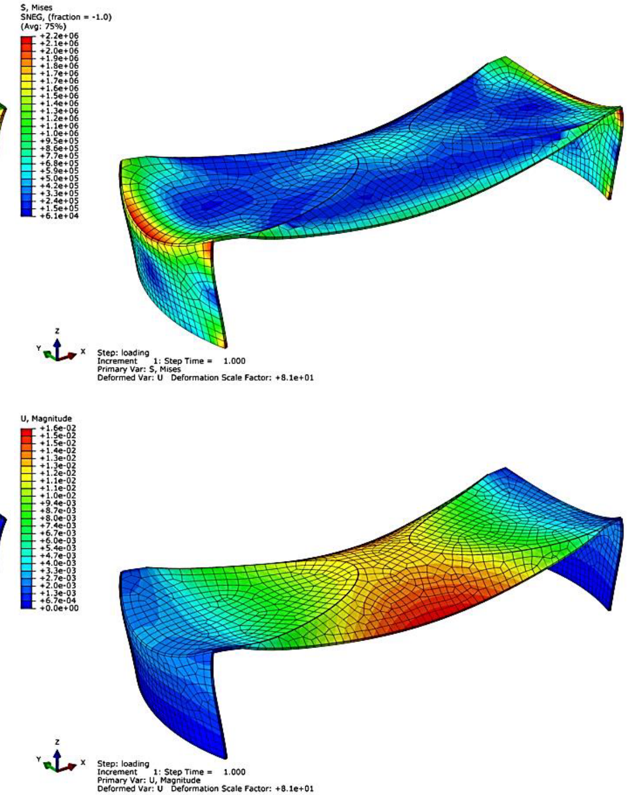
Full scale prototype: Deformations



Wind2



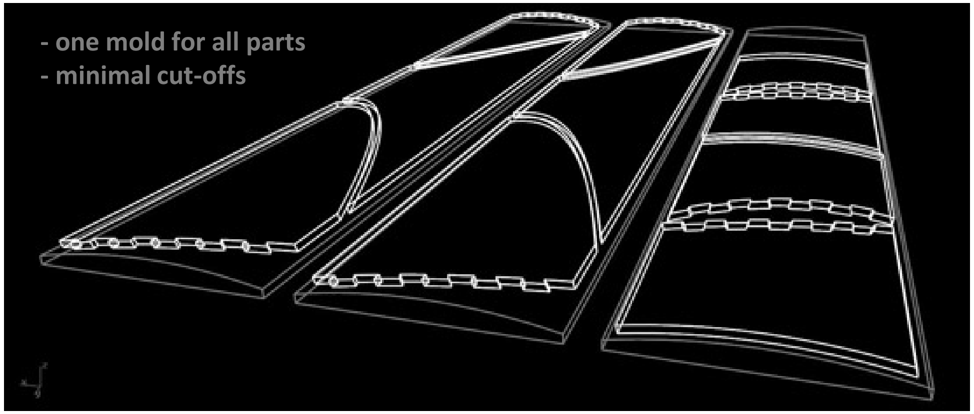
Wind1



Gravity

Sina Nabaei

Full scale prototype: Fabrication



3x Curved CLT Panel, length = 15m, radius = 5.9m, thickness = 77mm

Spruce boards with stress cuts

Lamination on mold

Panels ready for cutting

Full scale prototype: Fabrication

Christopher Robeller , Sina Nabaei

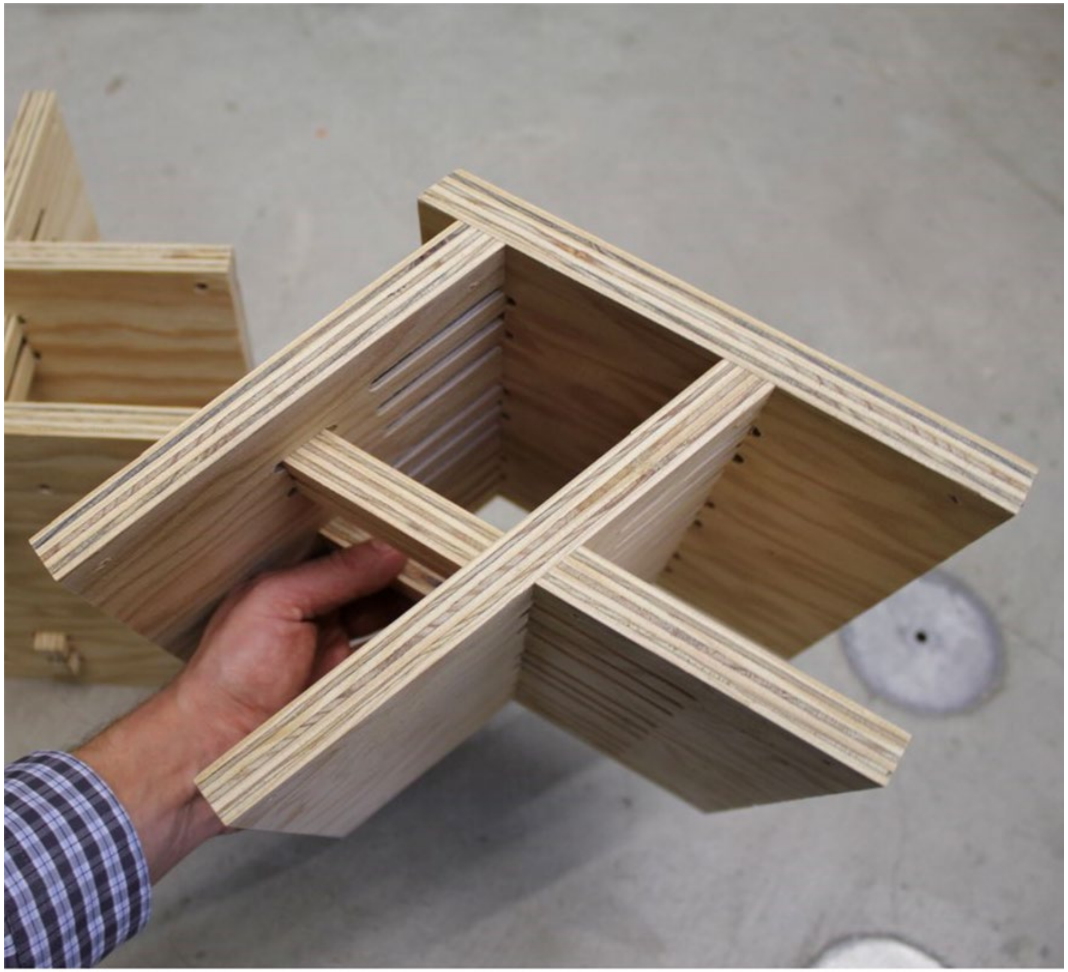
Full scale prototype: Fabrication

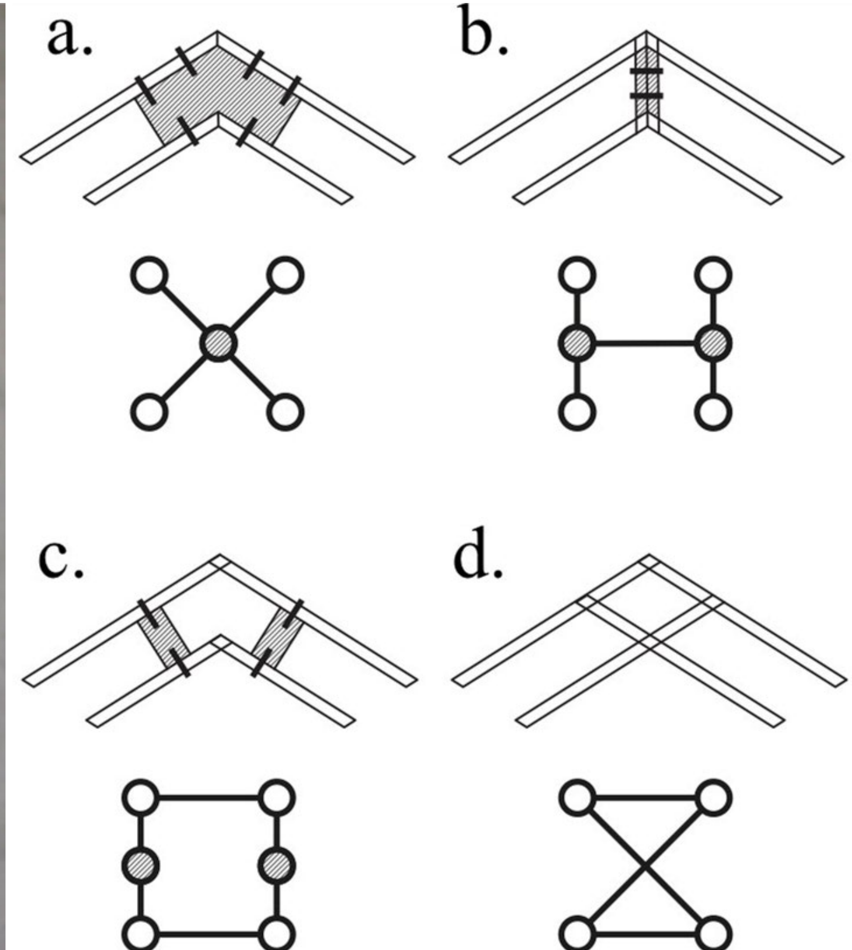
Full scale prototype: Fabrication

Christopher Robeller, Laurent Humber, Yves Weinand

Research

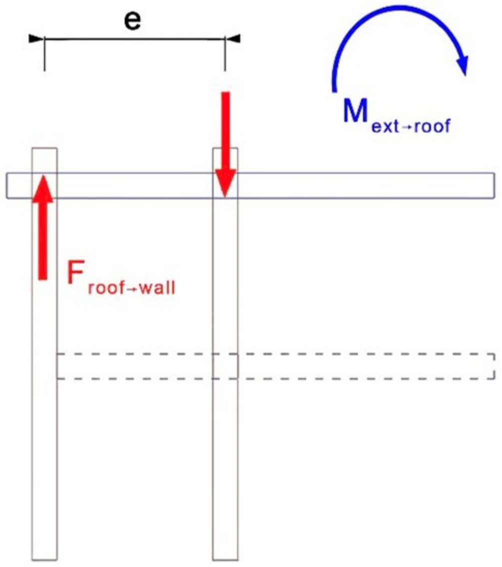
Double layer joint : research



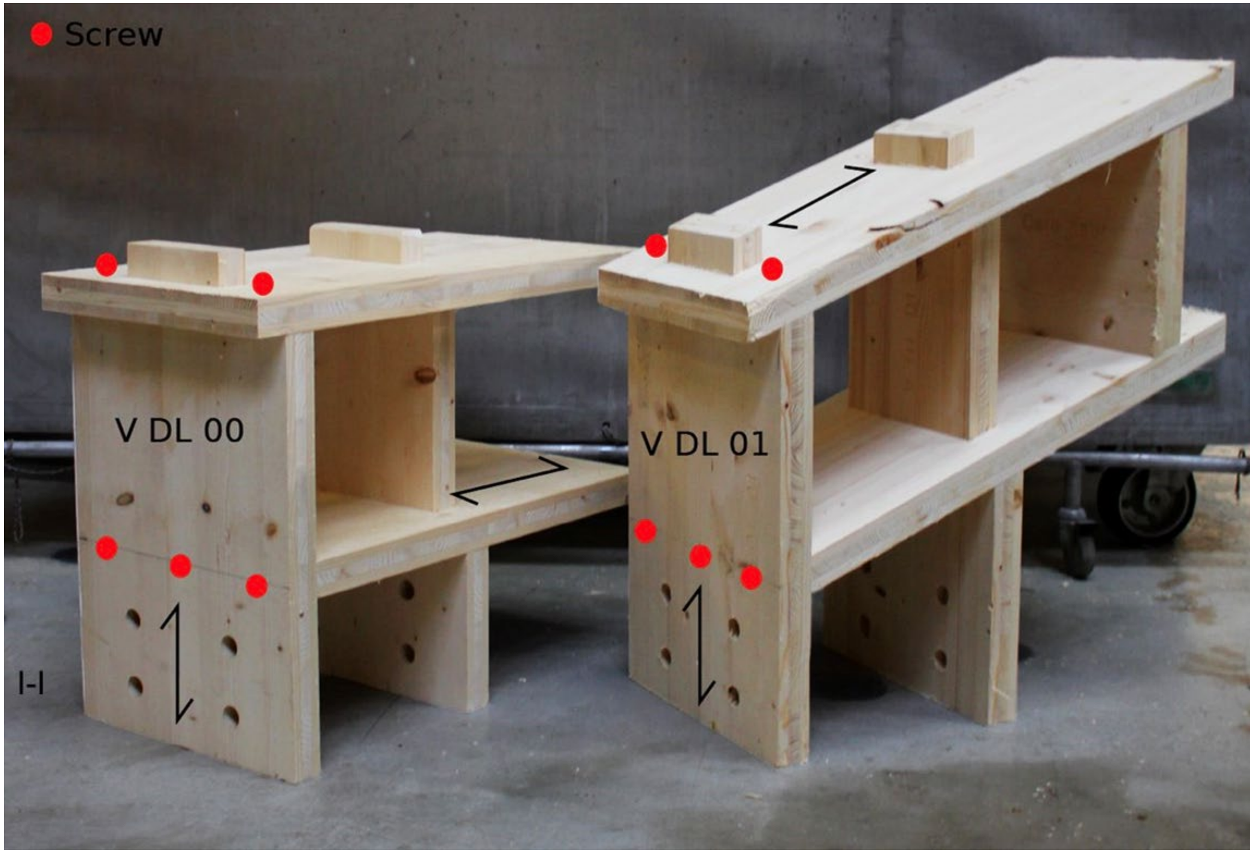


Andrea Stitic, Yves Weinand

Double layer joint : research



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



Andrea Stitic, Yves Weinand

Andrea Stitic, Yves Weinand

Weiterentwicklung von Faltwerken aus Holzplatten

2006 →

Einfach gekrümmt

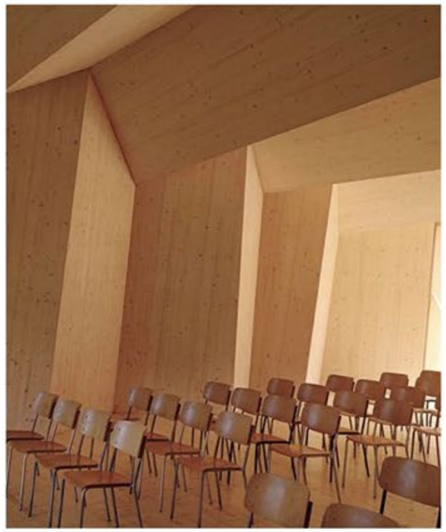
Gehrung

Einschichtig

Abwickelbar

8

2008 →



Rahmen

Gehrung

Einschichtig

Abwickelbar

39

2014 →

Zweifach gekrümmt

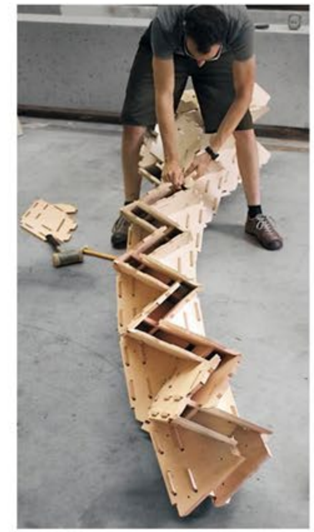
Schwalbenschwanzzinken

Einschichtig

Abwickelbar

107

2015



Zweifach gekrümmt

Zapfen-/Loch

Zweischichtig

Abwickelbar

152

Achieved Research

IBOIS ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Professional Practice
Teaching
Previous Research & Completed projects
Current Research & Applied projects

Nabucco

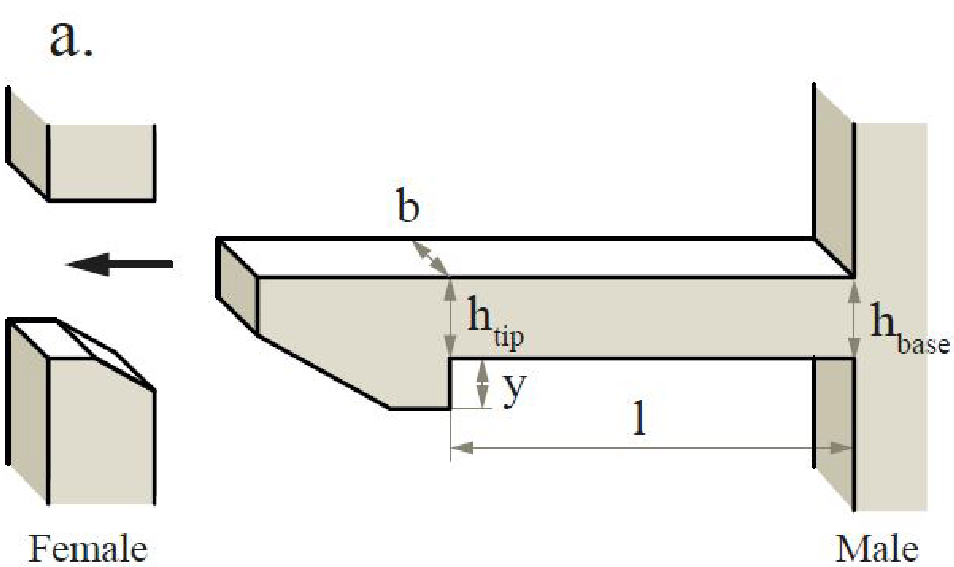
Annen Project

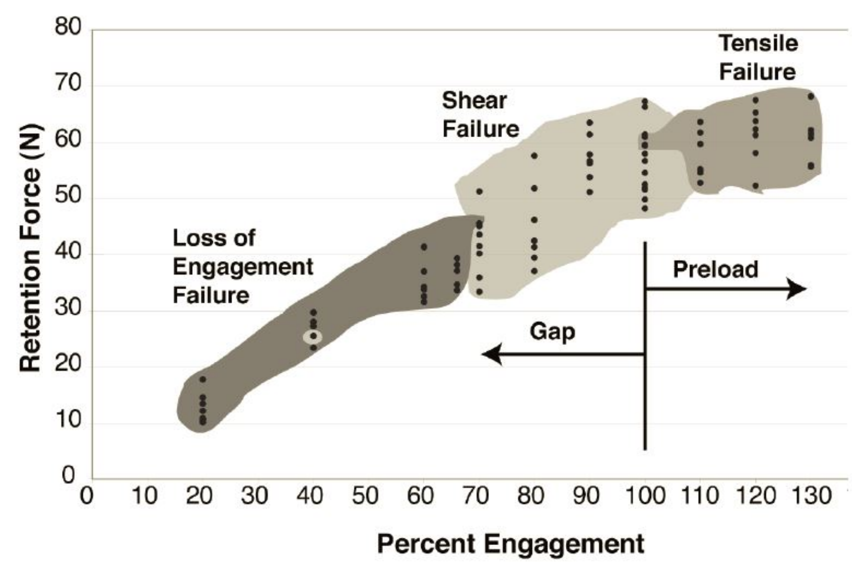
MOBIC

Centre d'Activité Grand Chalet

Liège Expo

Snap-Fit Joint, 2014 Acadia Design Agency, LA





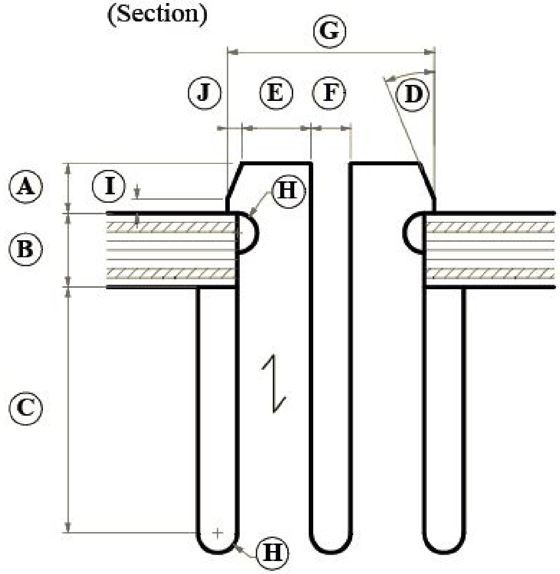
2 Retention Force Diagram (Courtesy of A. Luscher)

Chistophe Robeller, Paul Mayencourt, Yves Weinand

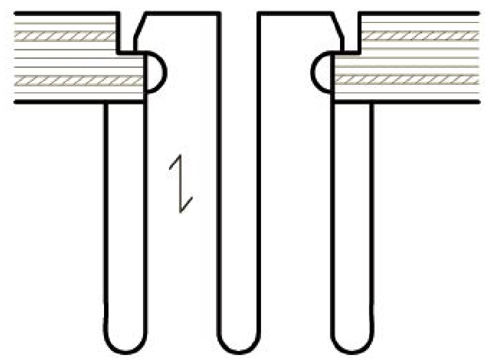
Research

Snap-Fit Joint

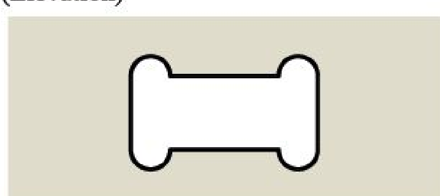
Protruding Snap
(Section)



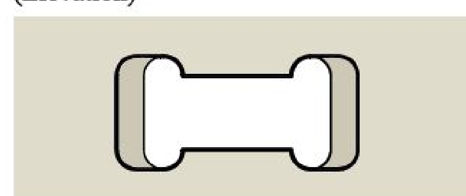
Non-protruding Snap
(Section)



Protruding Snap
(Elevation)



Non-protruding Snap
(Elevation)



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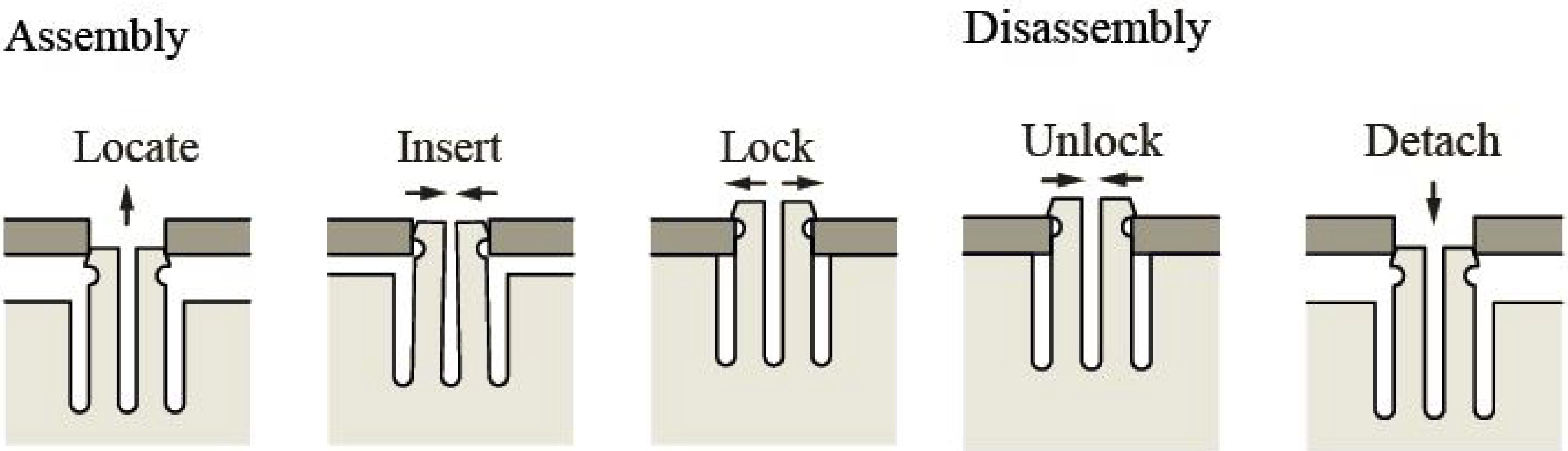

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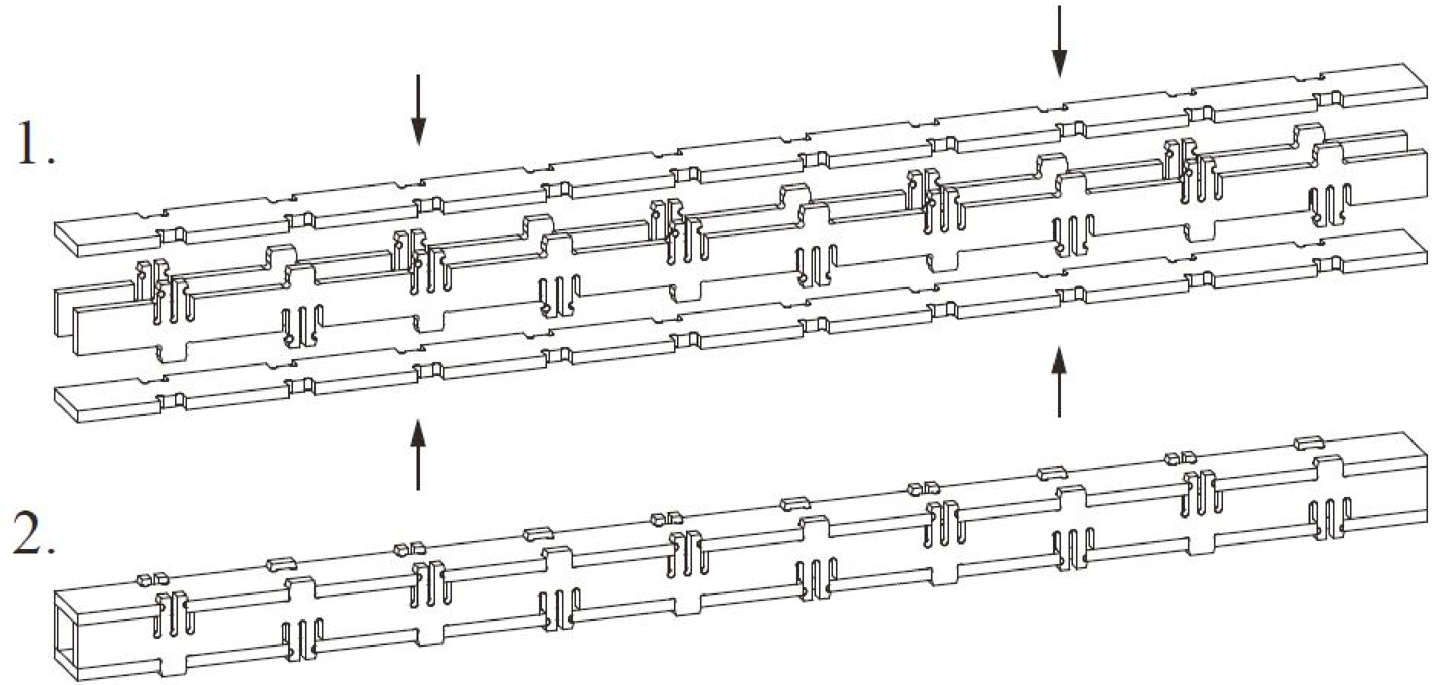

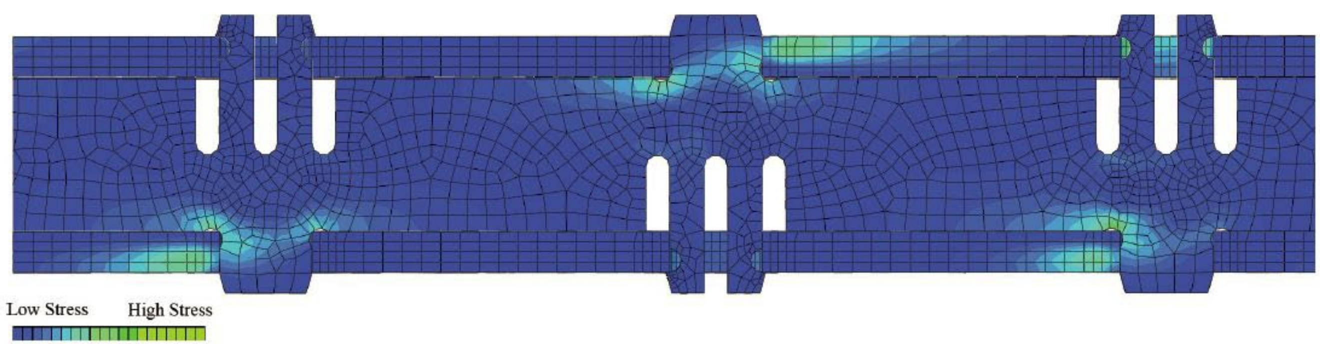

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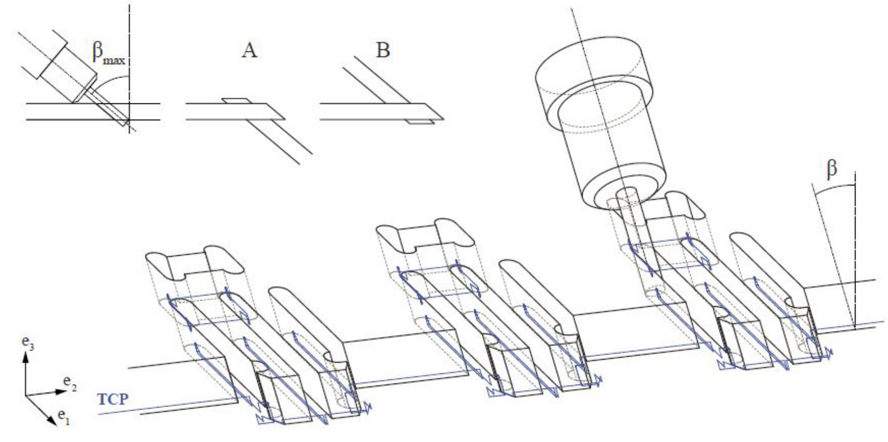

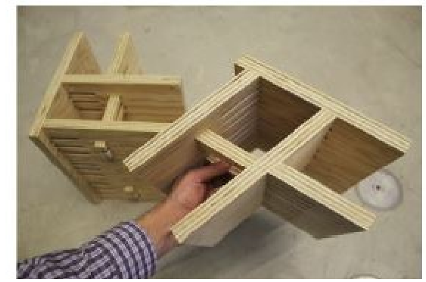

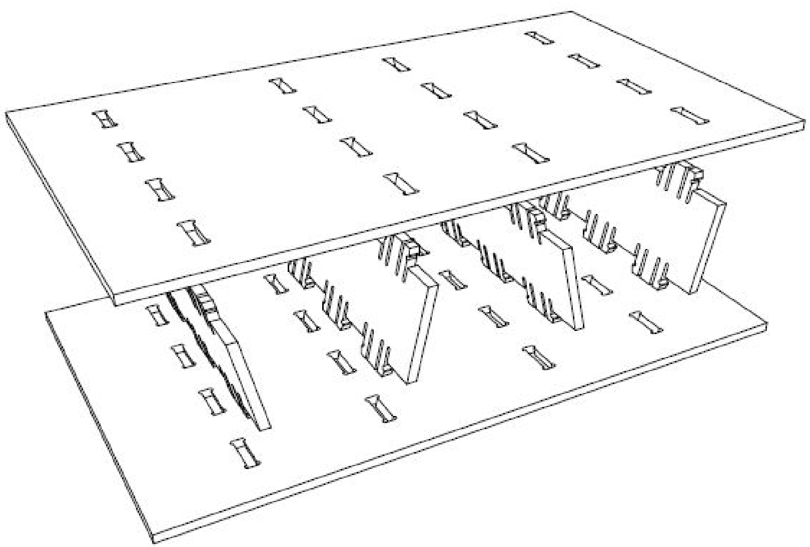

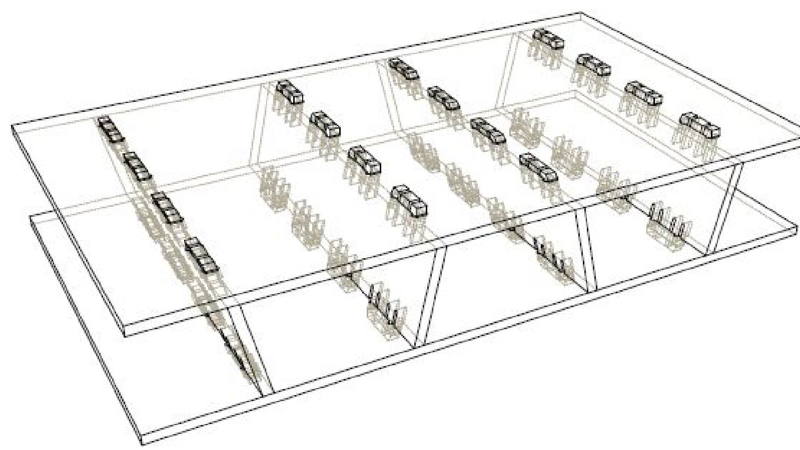

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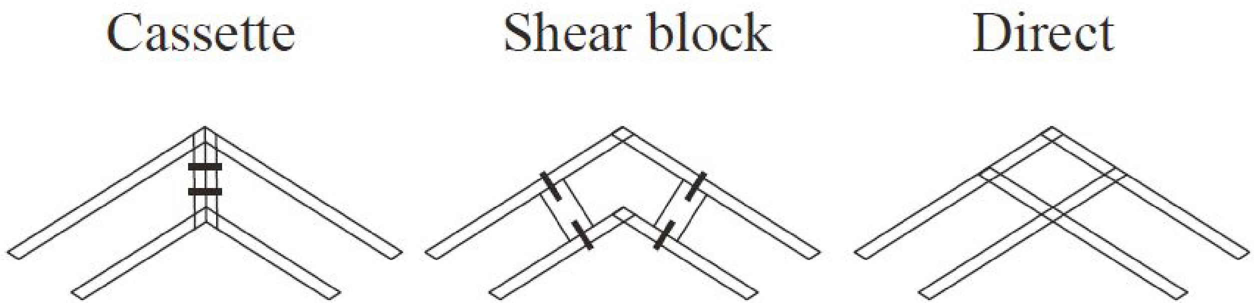
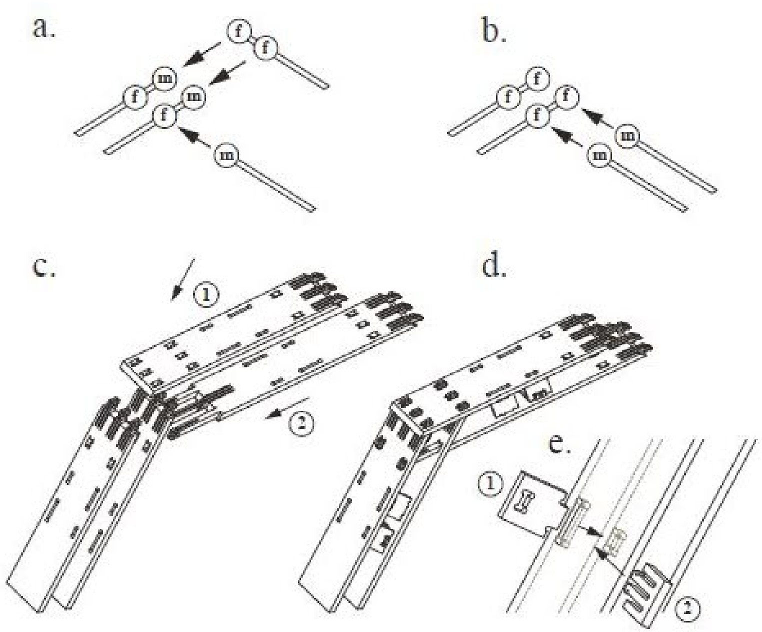
Research





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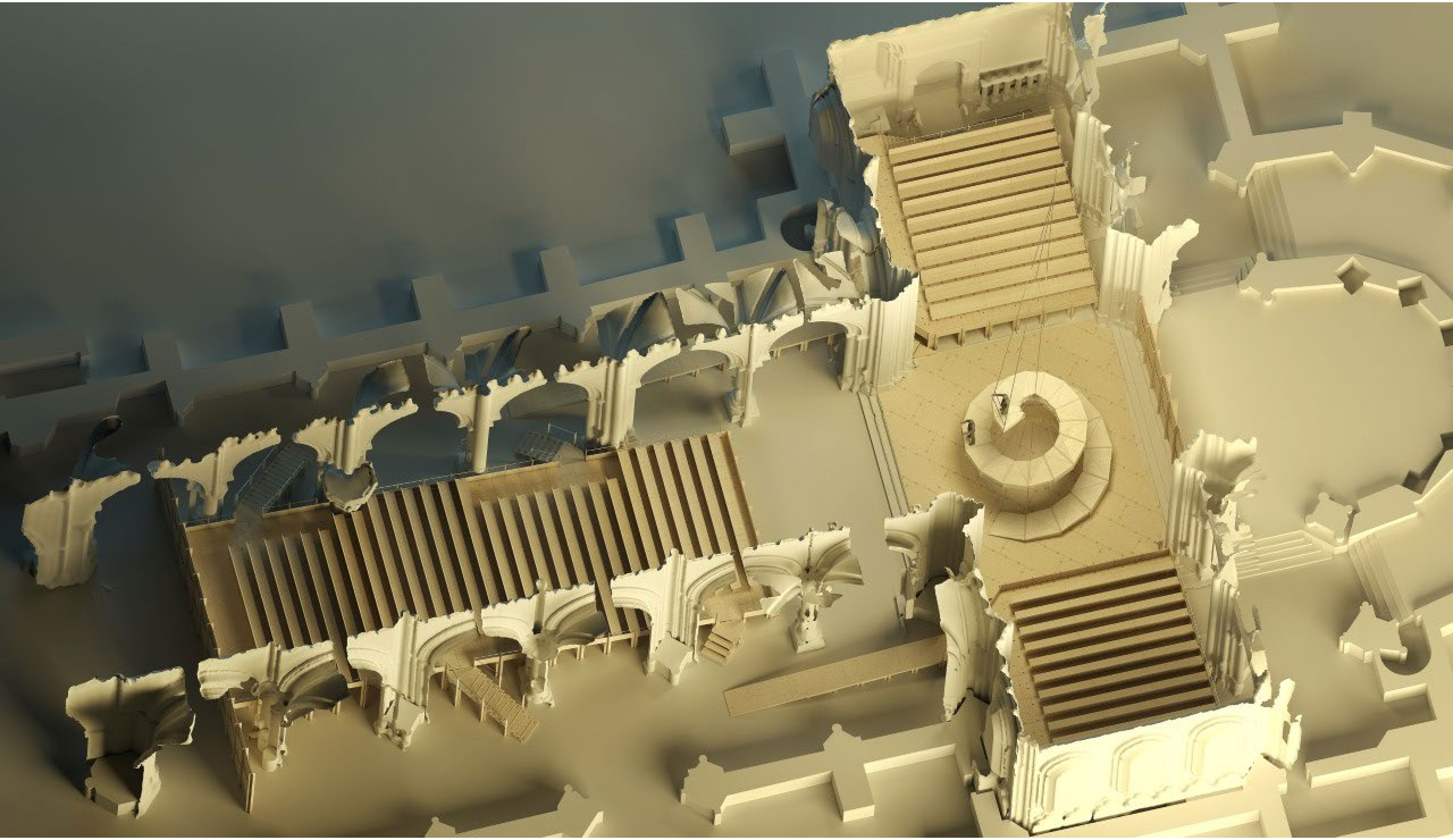
Research

Nabucco, Cathedral of Lausanne,
To be completed Nov.2018



Applied research

Prototypes of benches

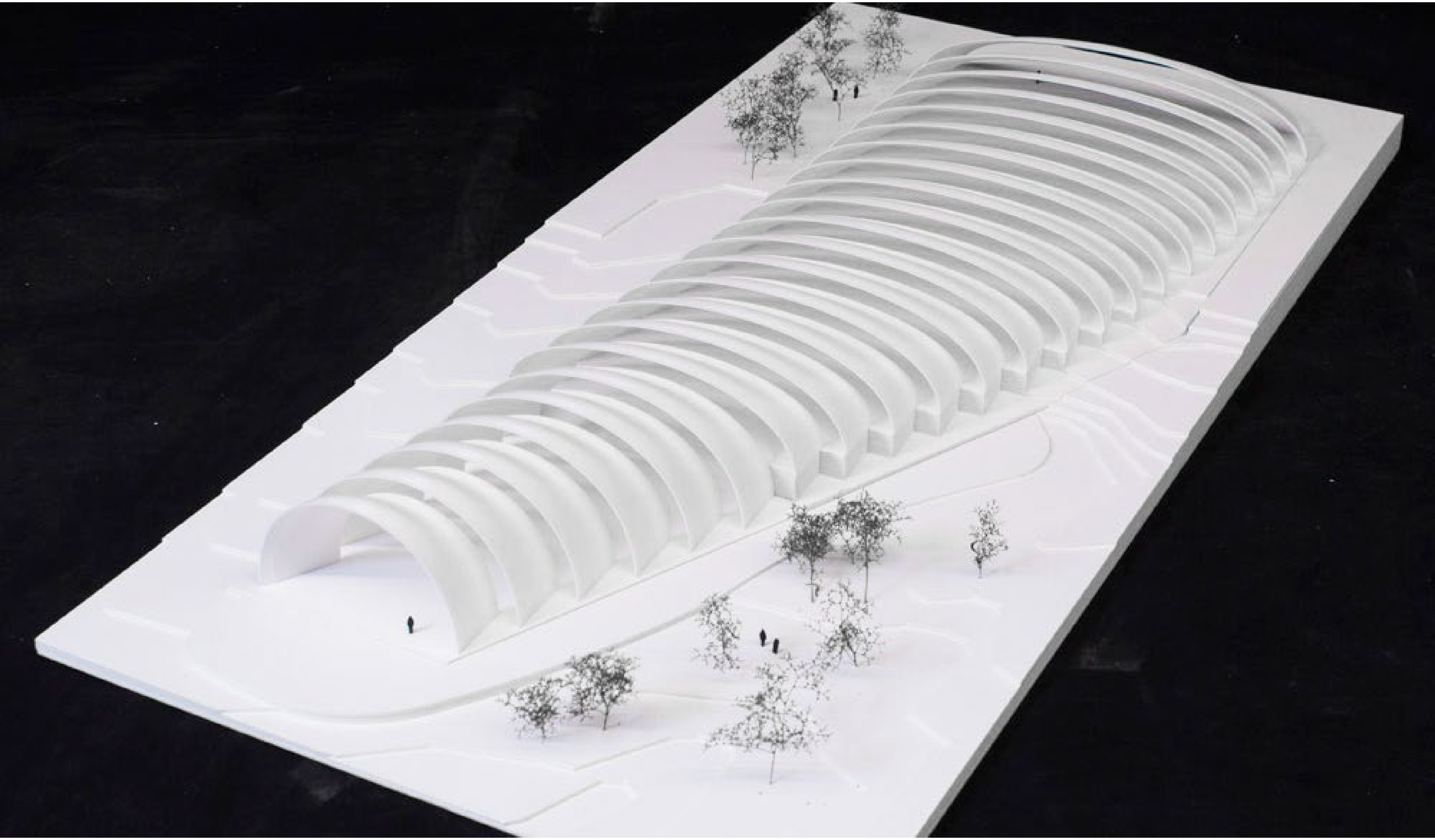
Applied research

Prototypes of benches

Applied research

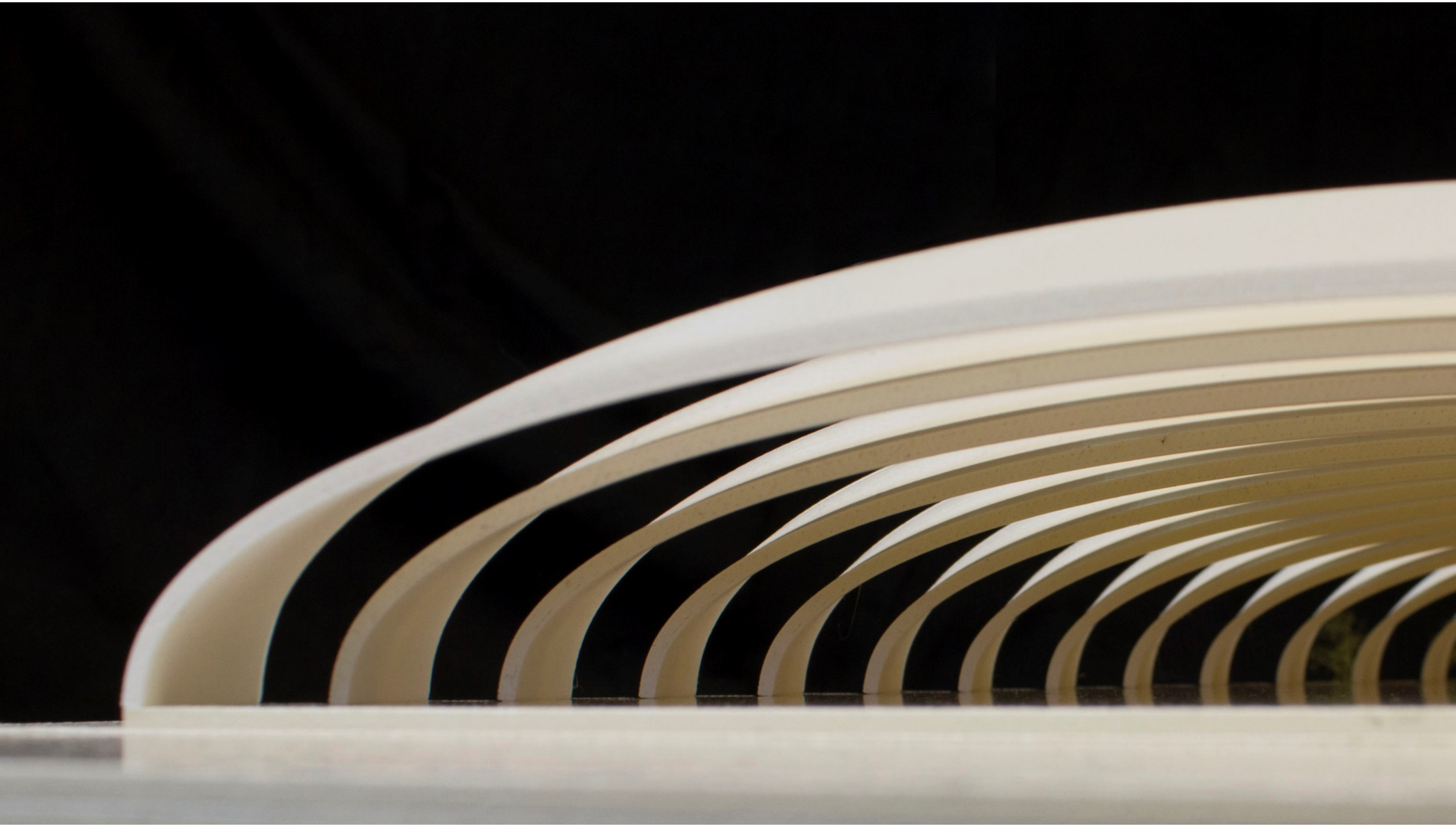
Professional Practice
Teaching
Previous Research & Completed projects
Current Research & Applied projects
Nabucco
Annen Project
MOBIC
Centre d’Activité Grand Chalet
Liège Expo

Annen Multipurpose Hall



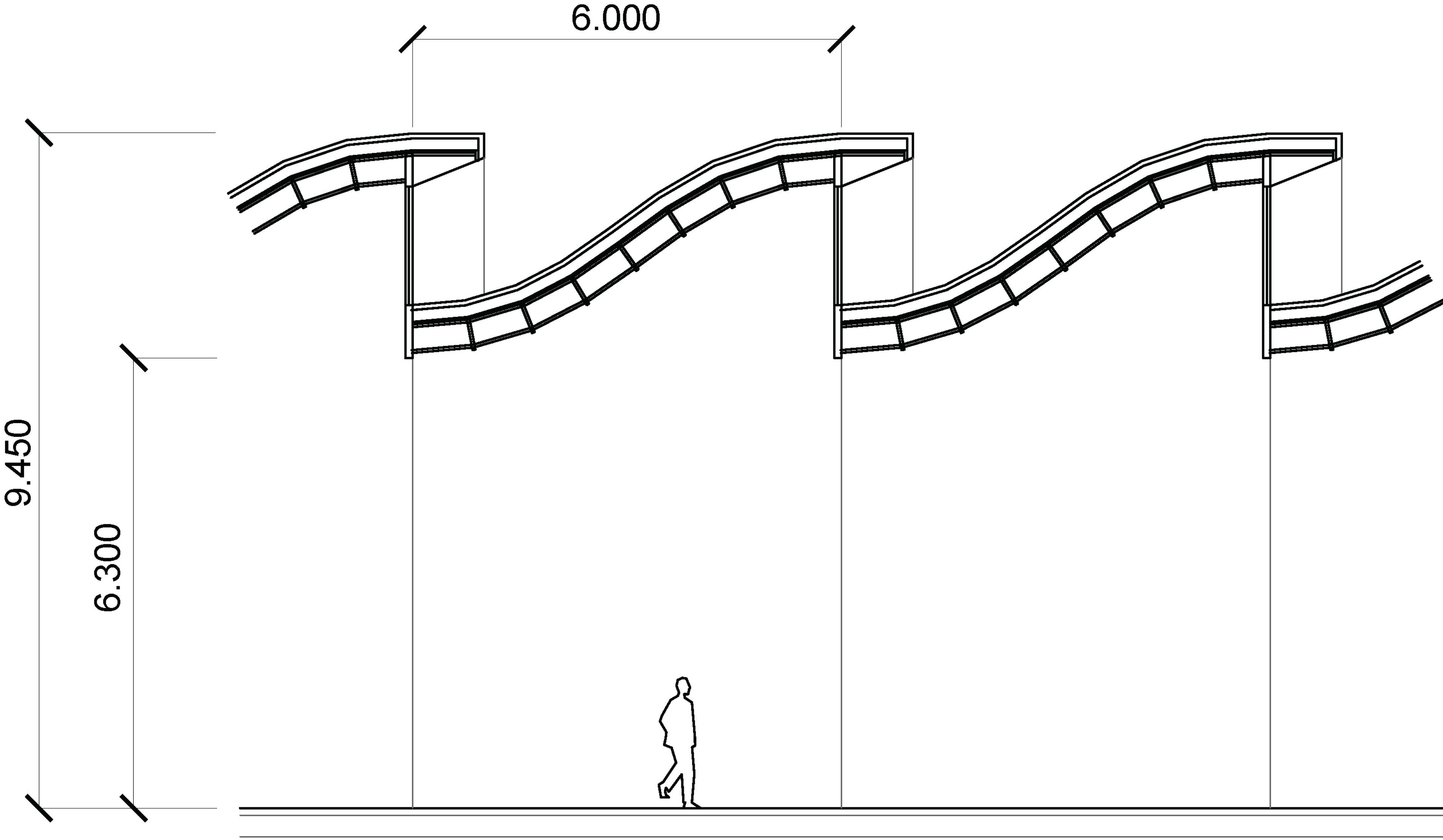
Christopher Robeller, Didier Callot, Anh Chi Nguyen, Aryan Rezaei Rad, Yves Weinand

Applied research

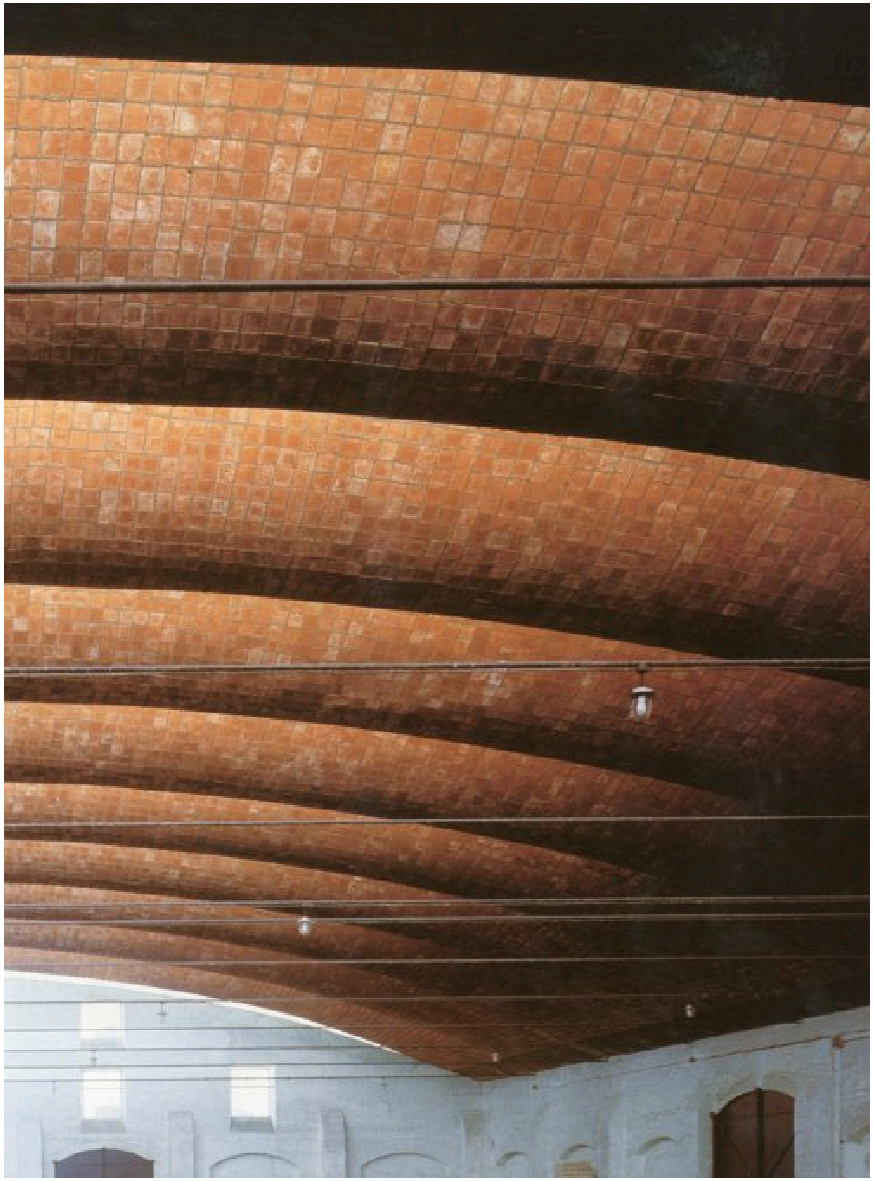


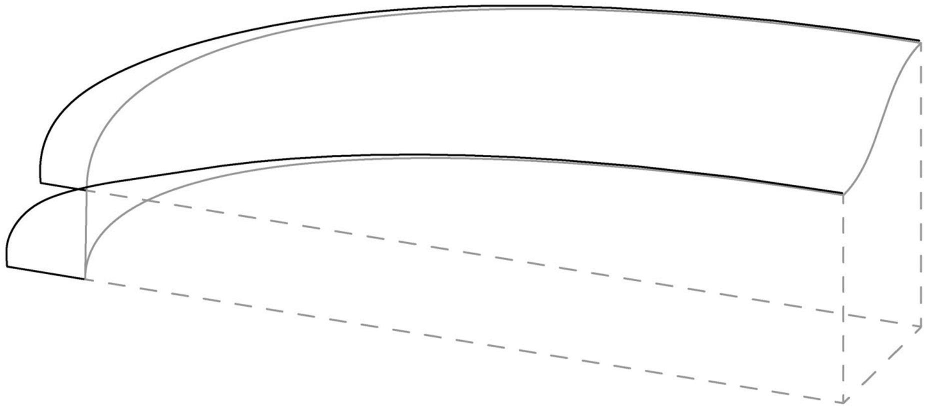
Christopher Robeller, Didier Callot, Anh Chi Nguyen, Aryan Rezaei Rad, Yves Weinand

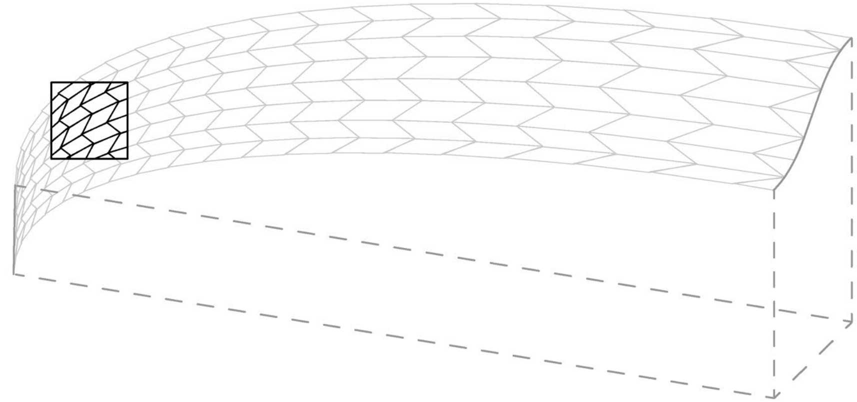
Applied research

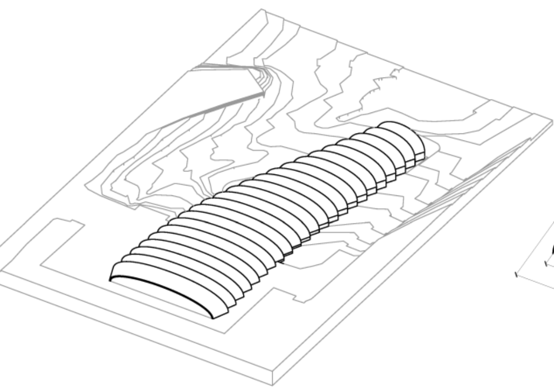


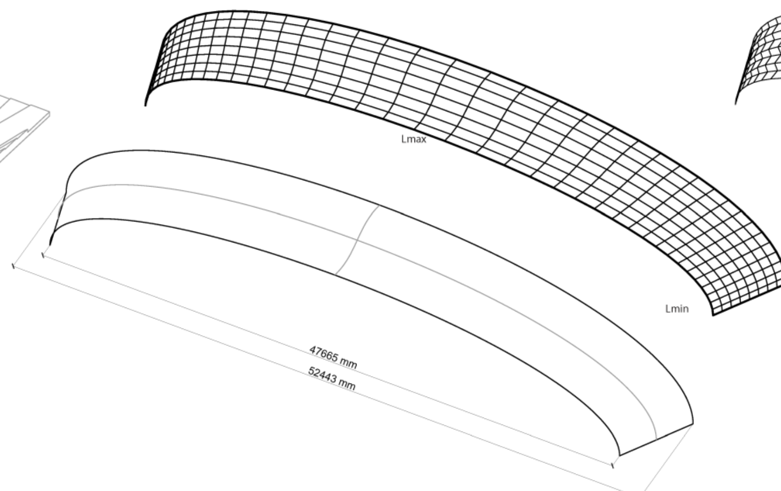
Christopher Robeller, Didier Callot, Anh Chi Nguyen, Aryan Rezaei Rad, Yves Weinand

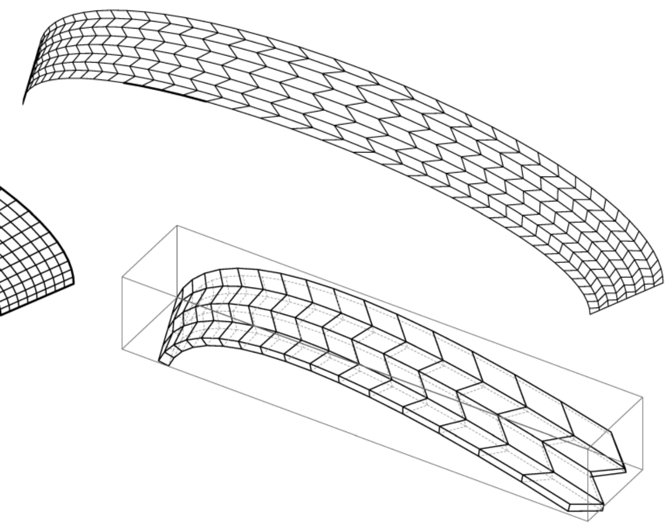












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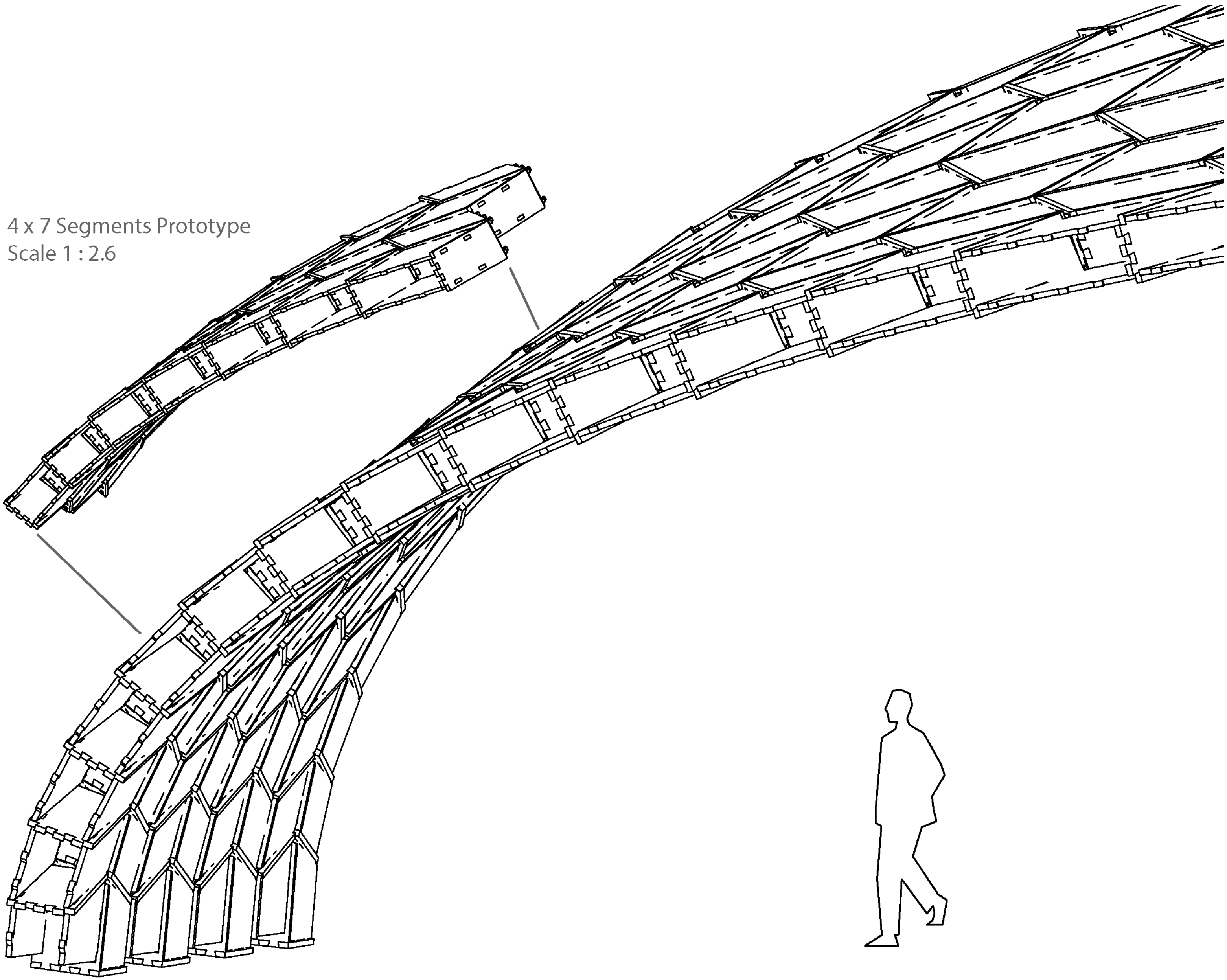
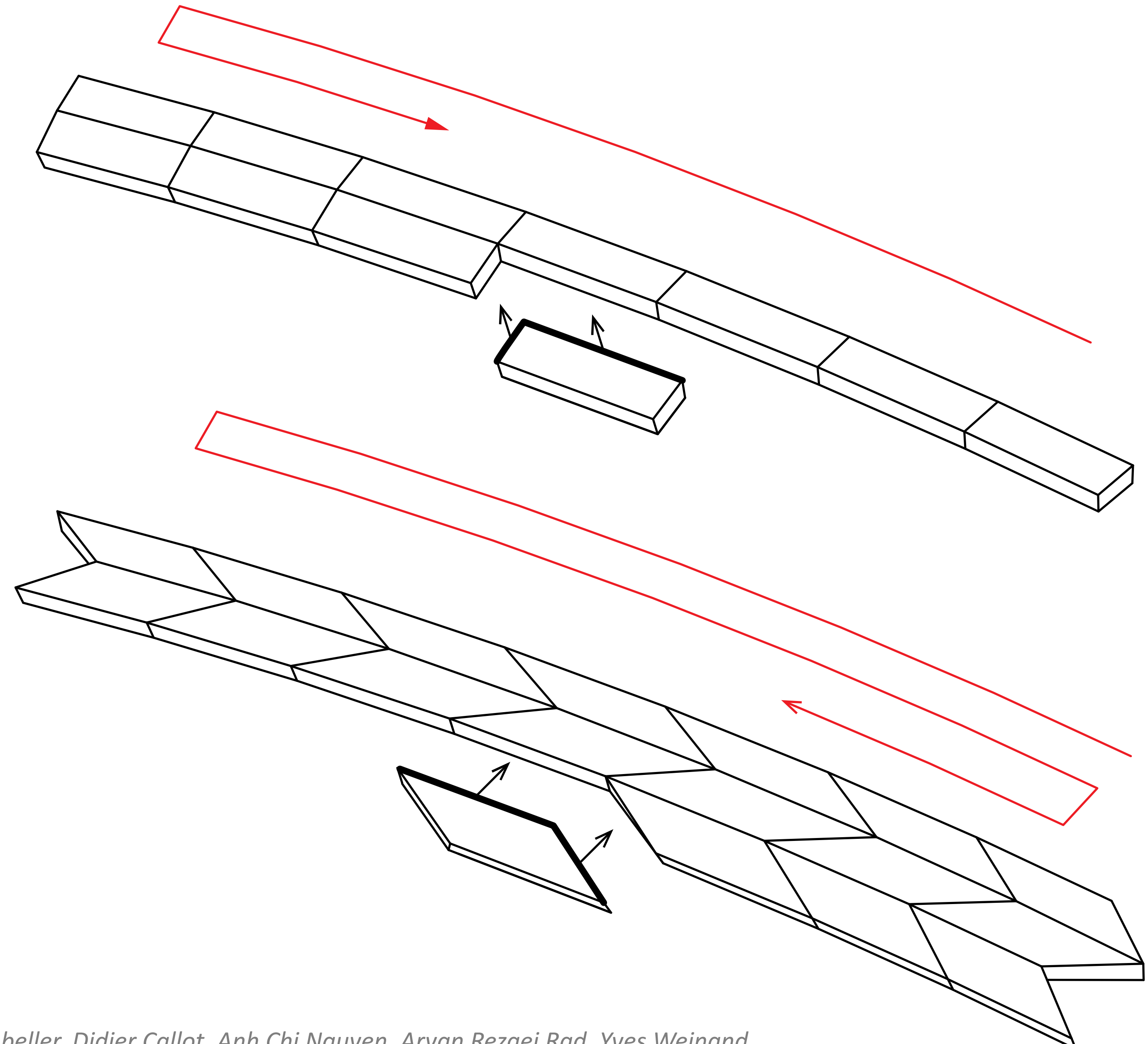
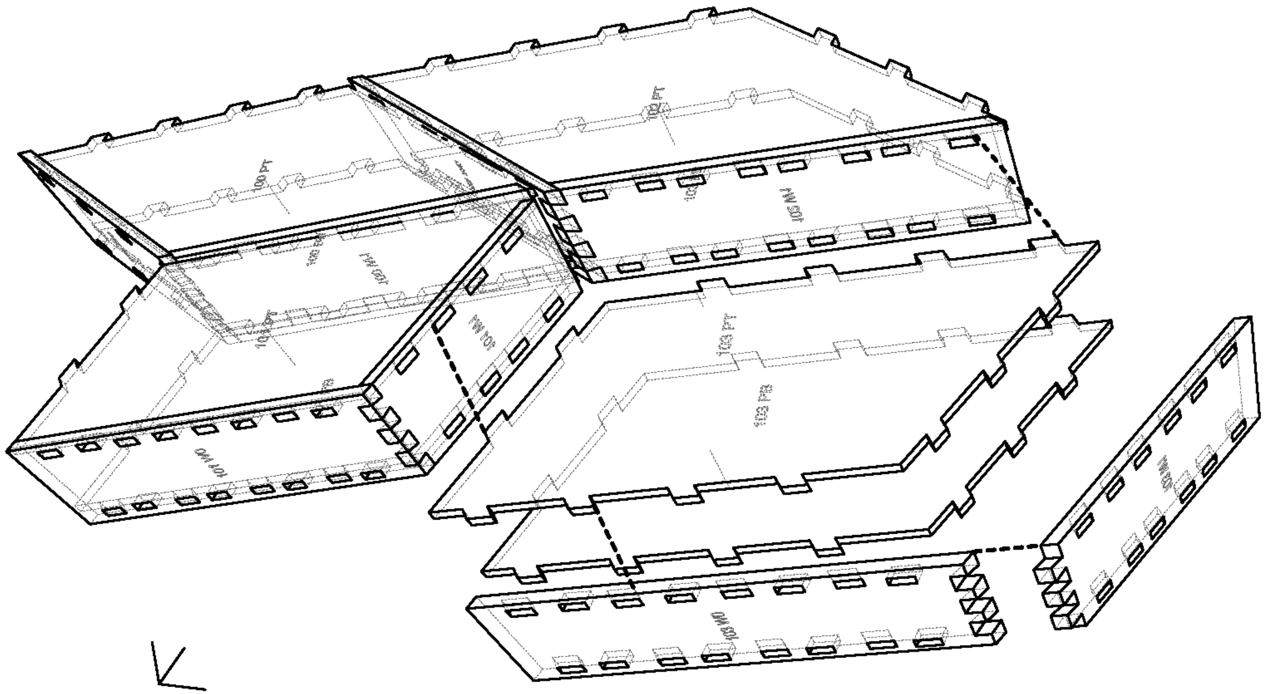
Applied research

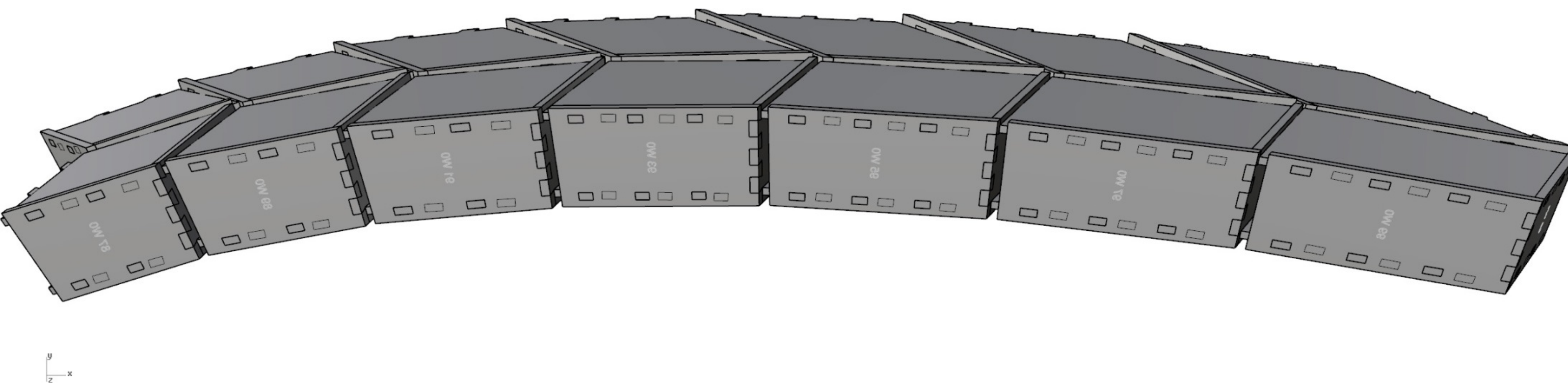

4 x 7 Segments Prototype
Scale 1 : 2.6



Christopher Robeller, Didier Callot, Anh Chi Nguyen, Aryan Rezaei Rad, Yves Weinand

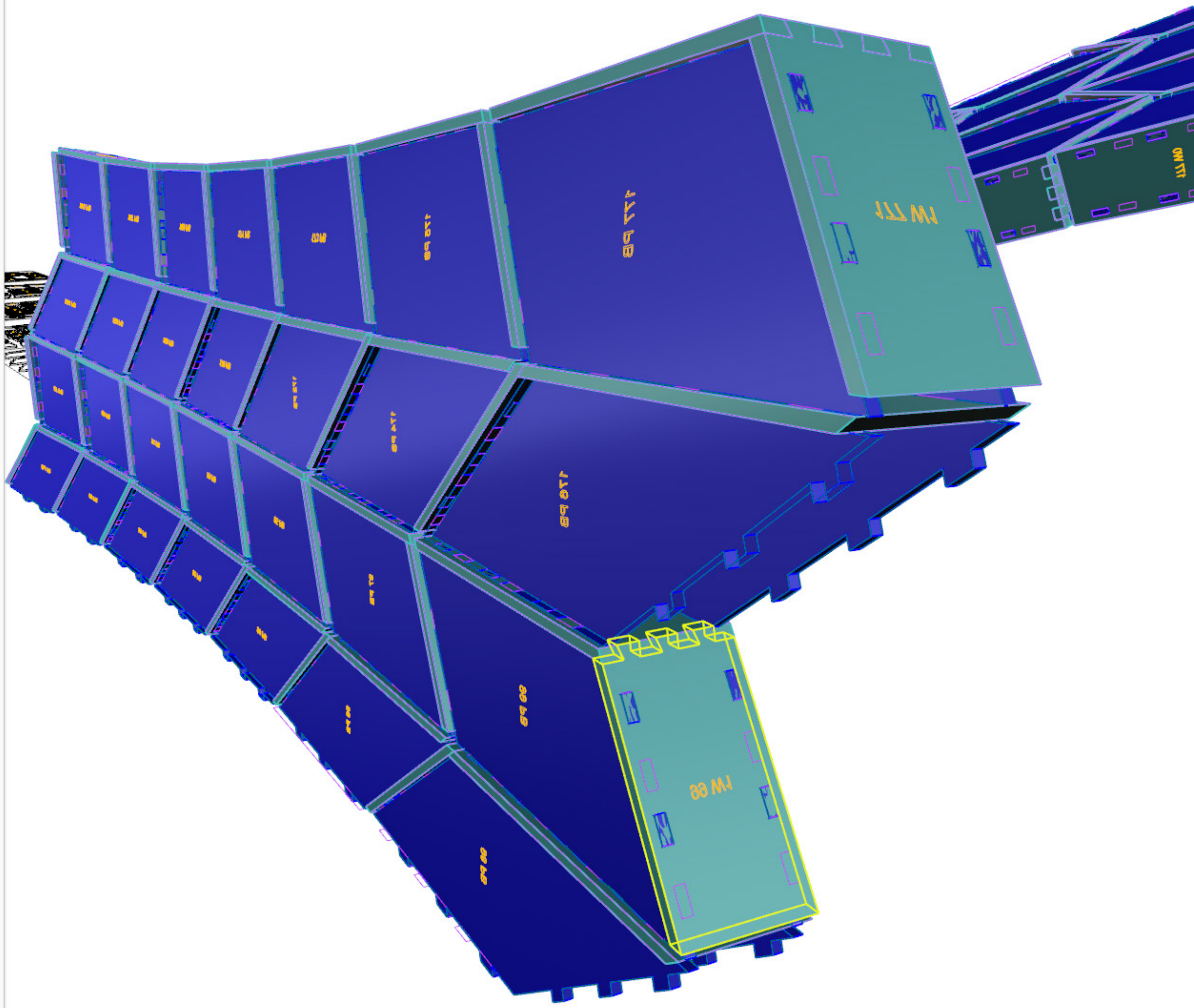
Applied research


100 PT
102 PT
103 PT
103 PB



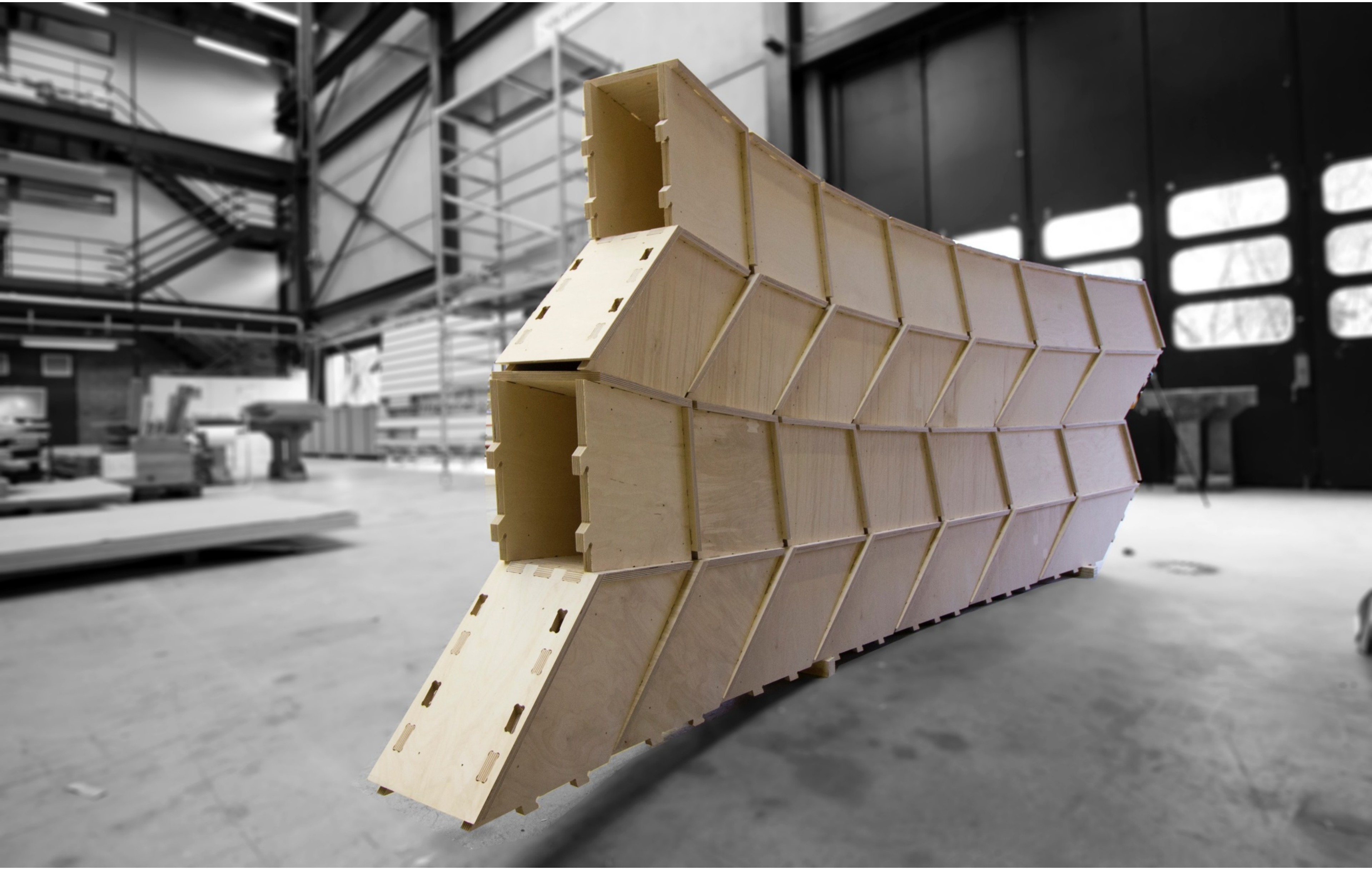
Christopher Robeller, Didier Callot, Anh Chi Nguyen, Aryan Rezaei Rad, Yves Weinand

Applied research



Christopher Robeller, Didier Callot, Anh Chi Nguyen, Aryan Rezaei Rad, Yves Weinand

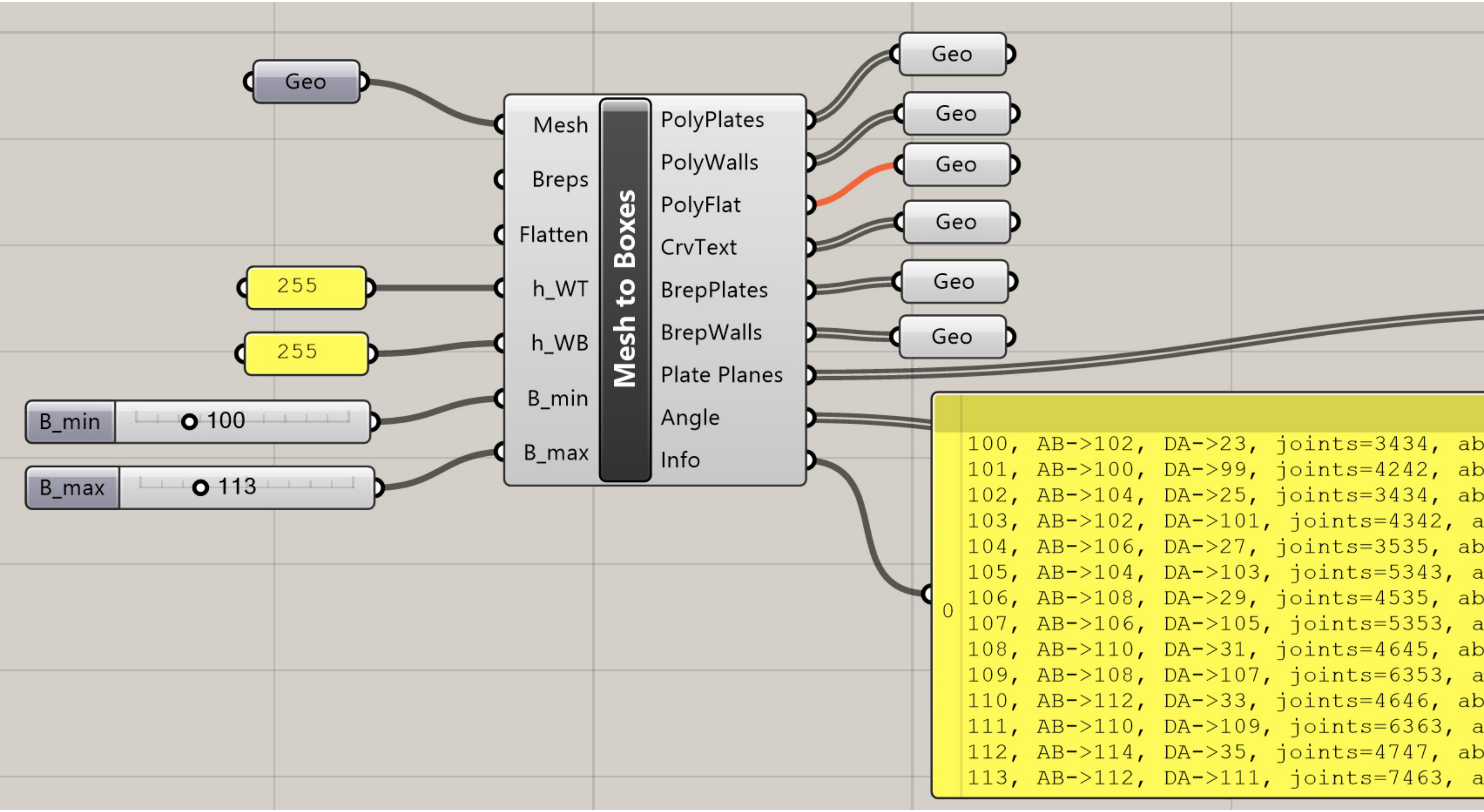
Applied research



Applied research

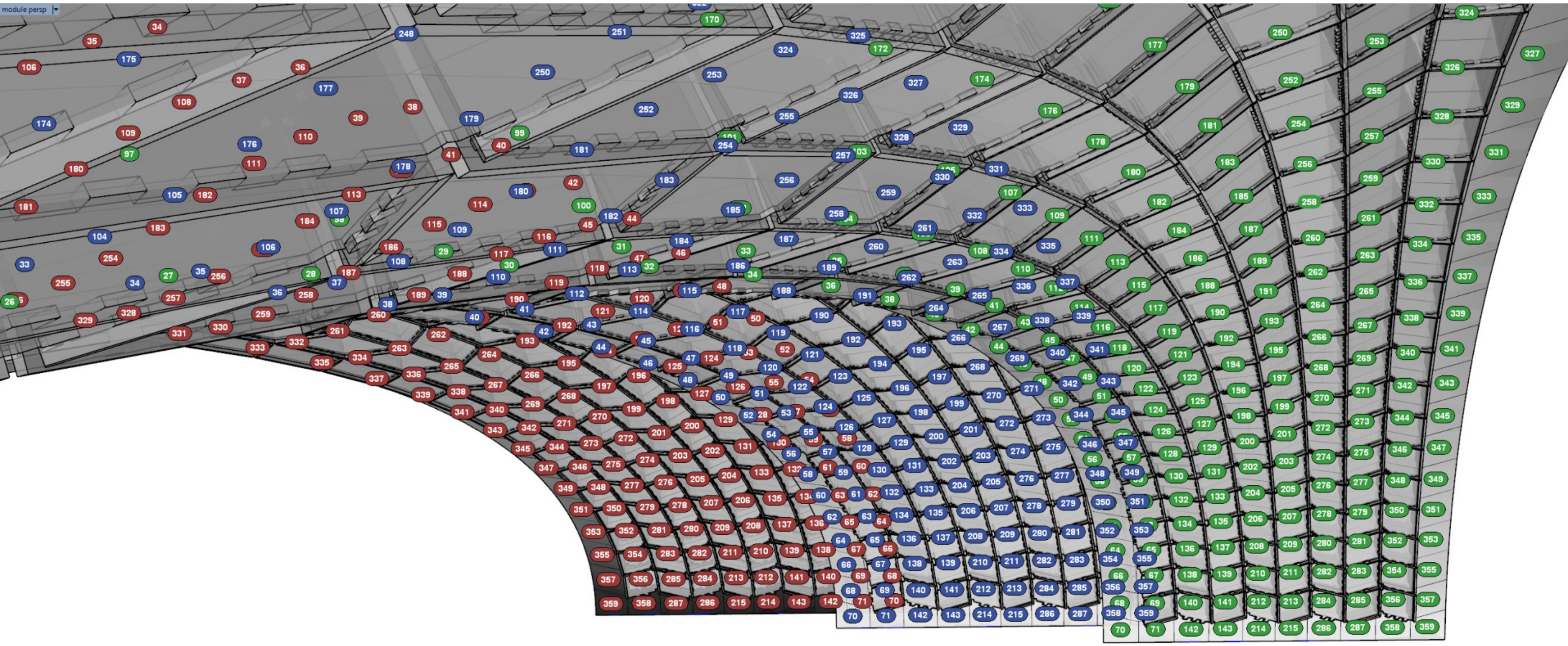
Applied research

Applied research



Christopher Robeller, Didier Callot, Anh Chi Nguyen, Aryan Rezaei Rad, Yves Weinand

Applied research



Christopher Robeller, Didier Callot, Anh Chi Nguyen, Aryan Rezaei Rad, Yves Weinand

Applied research

Applied research

Applied research

Customized & Advanced BIM / Schwebsange Demonstrator

36251	38308,0	optimized Meshes	0,0	22_196_3_breps	0;0;0	solid			1742016,7	262
36252	38309,0	optimized Meshes	0,0	22_197_0_breps	0;0;0	solid			2262646,5	257
36253	38310,0	optimized Meshes	0,0	22_197_1_breps	0;0;0	solid			2176714,1	258
36254	38311,0	optimized Meshes	0,0	22_197_2_breps	0;0;0	solid			1718017,5	254
36255	38312,0	optimized Meshes	0,0	22_197_3_breps	0;0;0	solid			1916217,7	263
36256	38313,0	optimized Meshes	0,0	22_198_0_breps	0;0;0	solid			1997877,5	271
36257	38314,0	optimized Meshes	0,0	22_198_1_breps	0;0;0	solid			1932955,7	273
36258	38315,0	optimized Meshes	0,0	22_198_2_breps	0;0;0	solid			1369356,3	267
36259	38316,0	optimized Meshes	0,0	22_198_3_breps	0;0;0	solid			1624839,1	273

Schwebsange Prototype 1:1

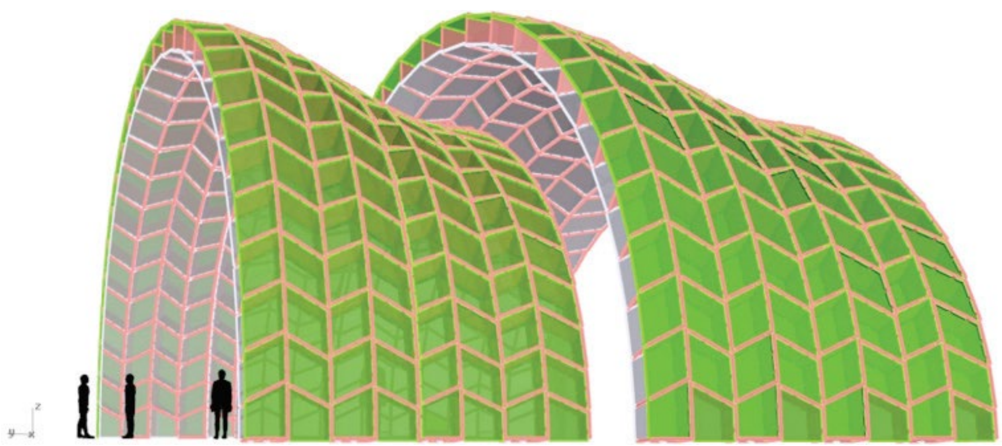
L-5447 Schwebsange, Luxembourg

NURBS Fläche Bogen 22: 192 m2
NURBS Fläche Bogen 21: 203 m2 (+6%)

Platten Bogen 22 mit Verbindungen:

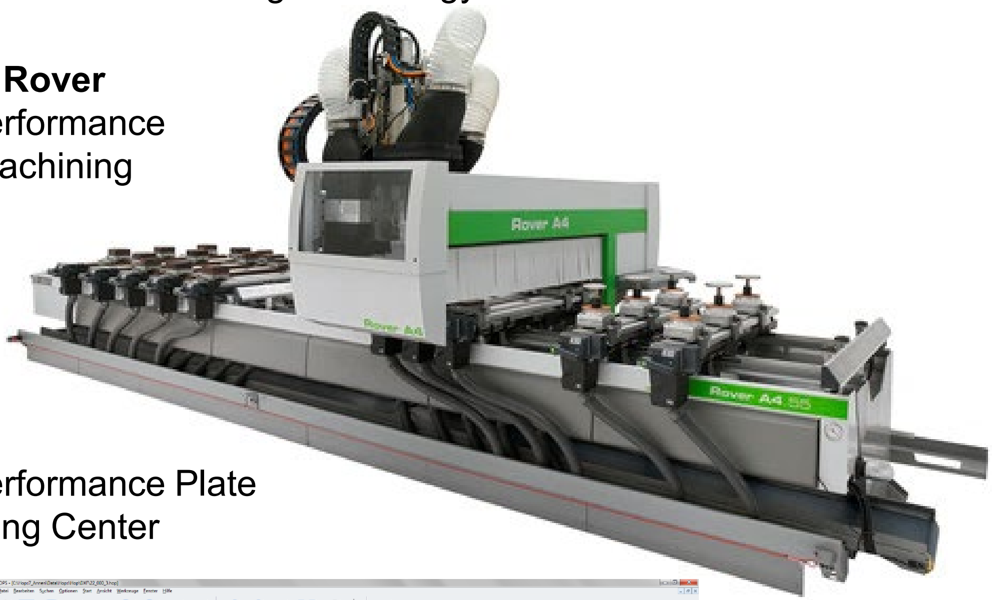
- Platten Total 660 m2
- Obere Plattenlage 182 m2
- Untere Plattenlage 172 m2
- Zwischenlage 304 m2

Total 1.000 m2

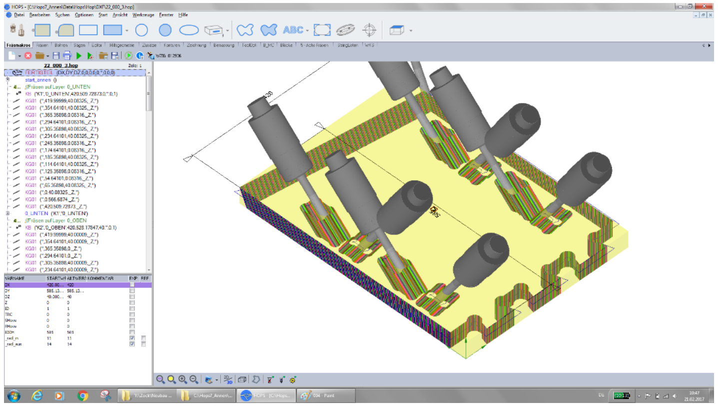


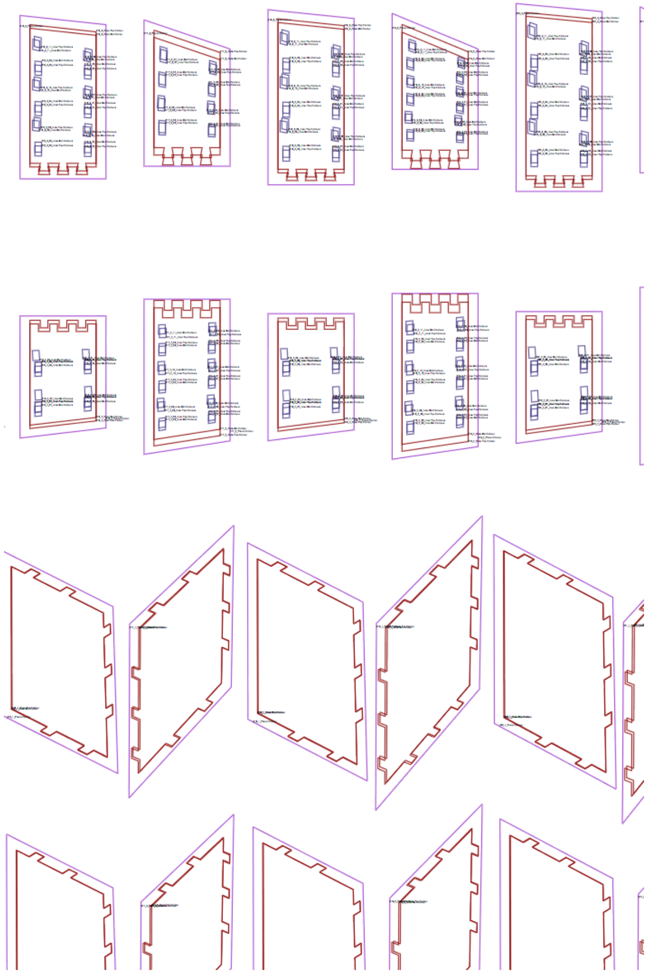
Advanced Manufacturing Technology

Biesse Rover
High-performance
Plate Machining
Center

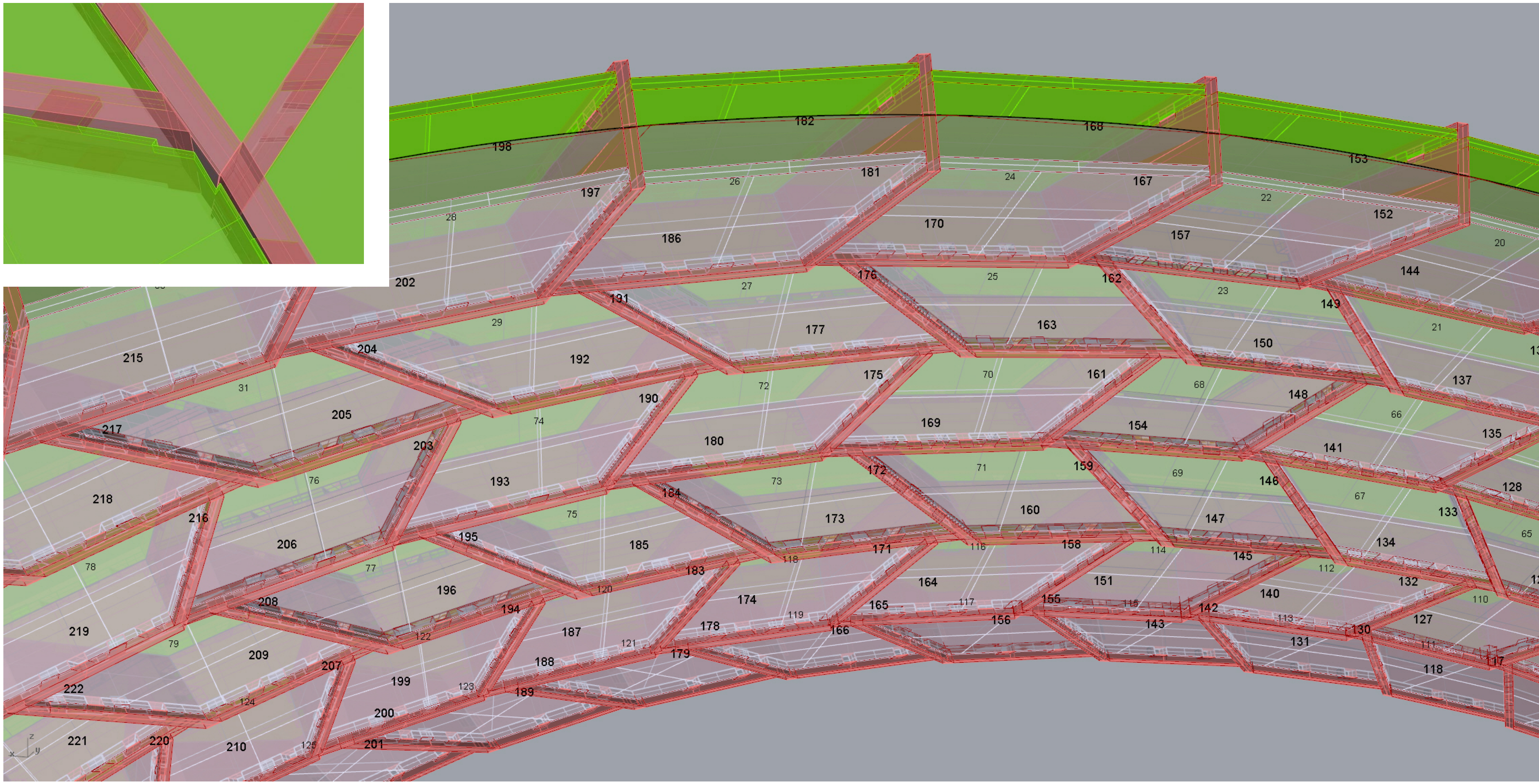


High-performance Plate
Machining Center

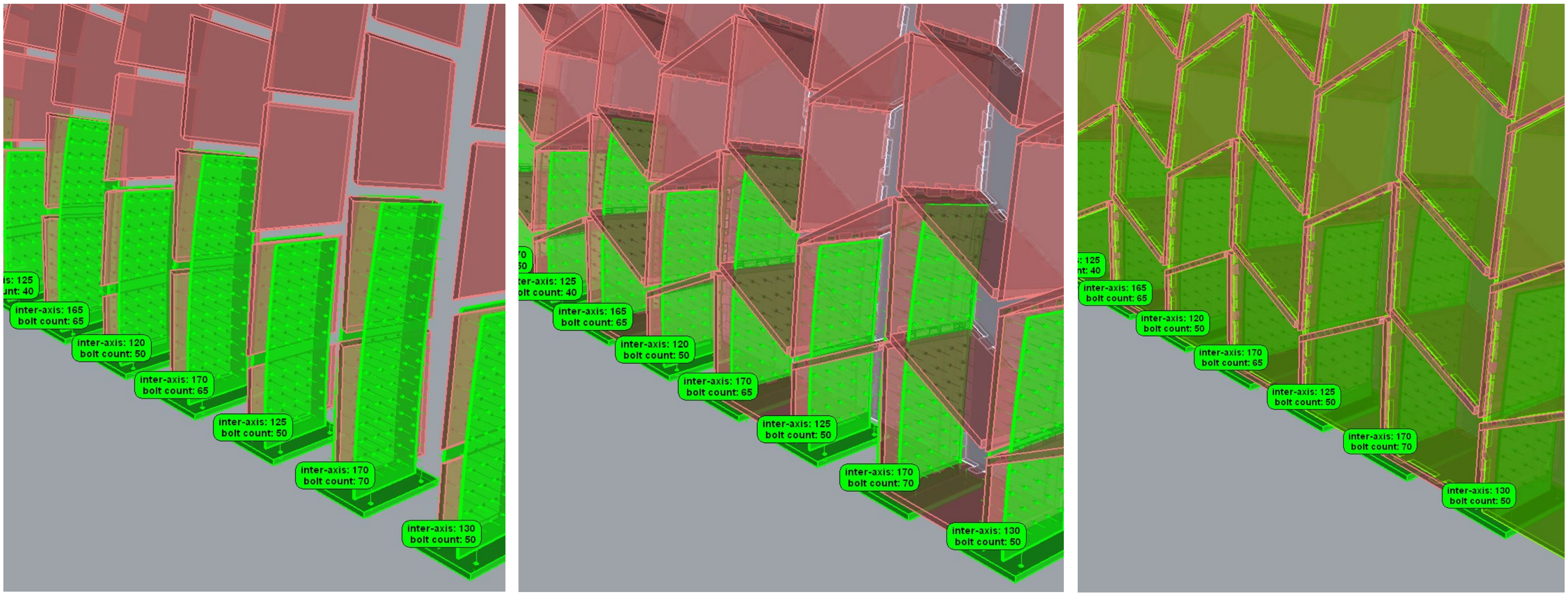




Further development of integrally attached timber plate construction systems



Collaborative Integration of Complex Details



Applied research

IBOIS ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Professional Practice

Teaching

Previous Research & Completed projects

Current Research & Applied projects

Nabucco

Annen Project :

Modeling of through tenon joints in double layered timber plate shells

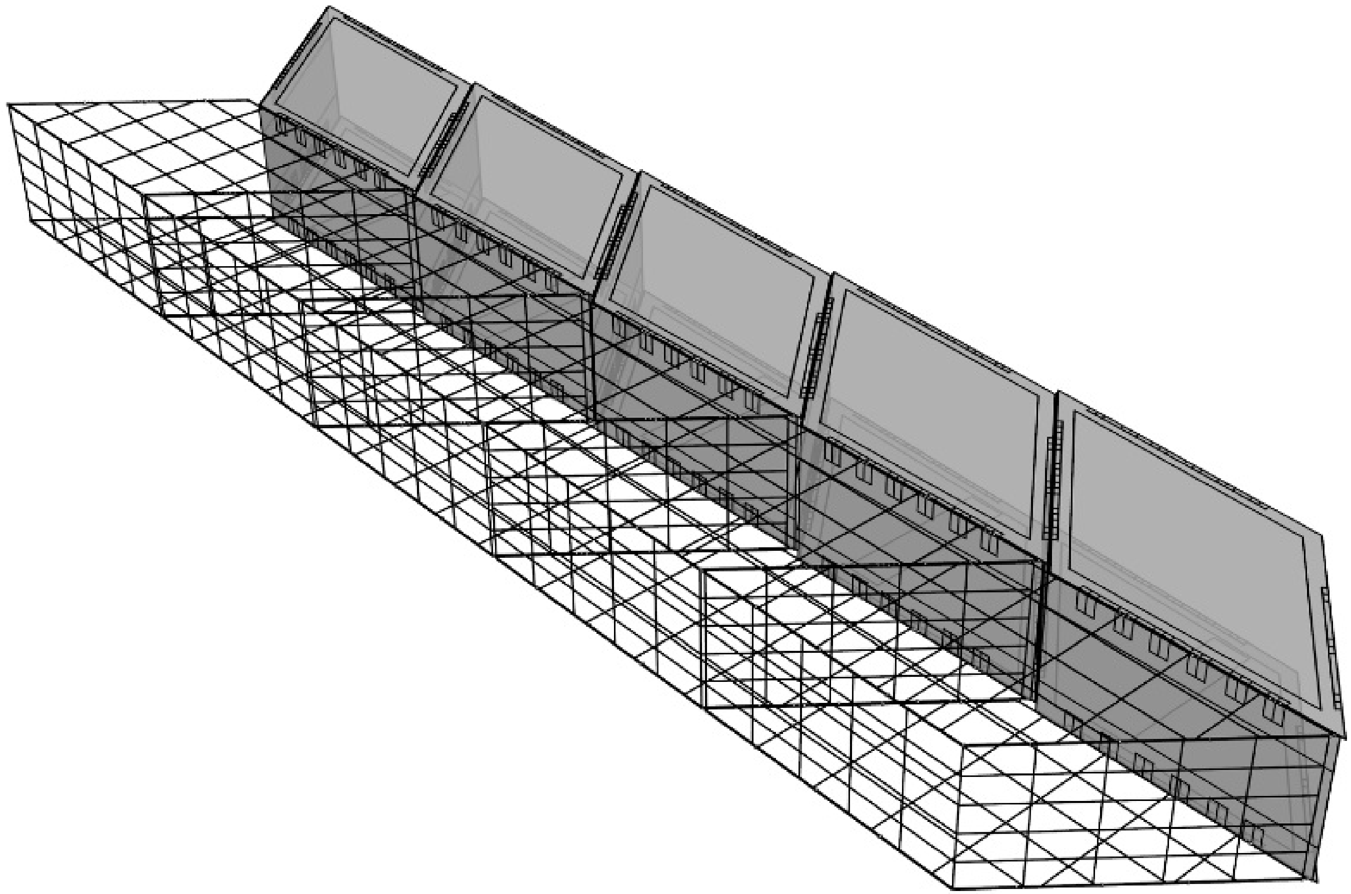
Mechanical Characterization of integrally attached timber plate structures

MOBIC

Centre d’Activité Grand Chalet

Liège Expo

Summary



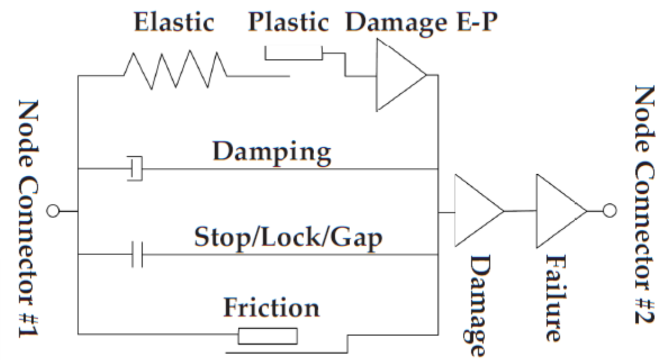
Macro Models vs. FE models

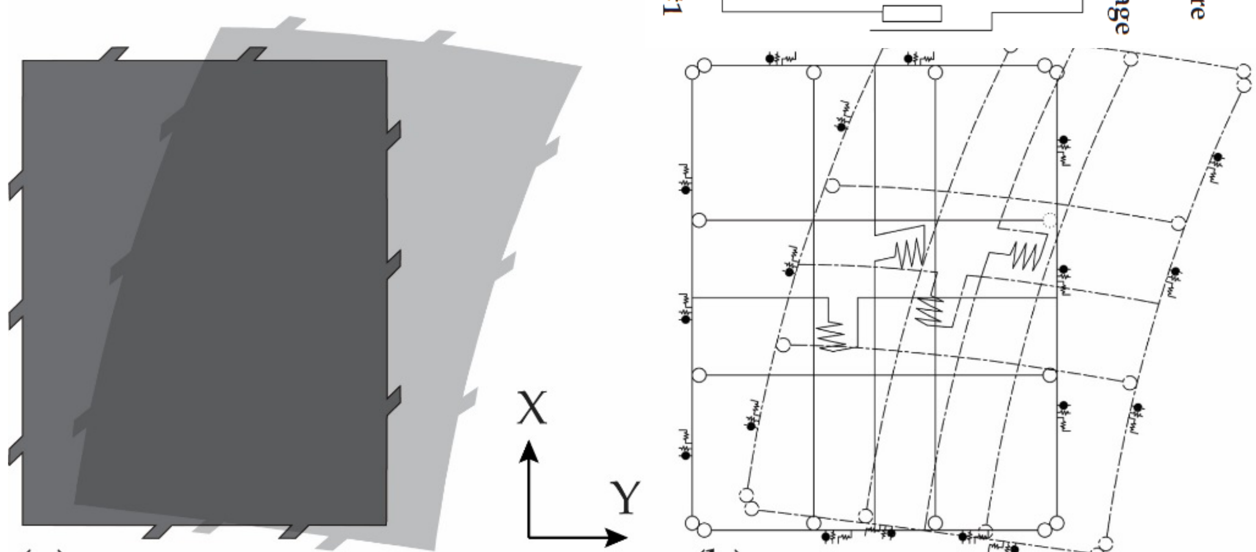
Aryan Rezaei Rad

$$\text{Section Compatibility: } \varepsilon(x, y, z) = a_s(y, z) e(x)$$

$$\text{Section Equilibrium: } s(x) = \int_A a_s{}^T(y, z) \sigma \, dA$$

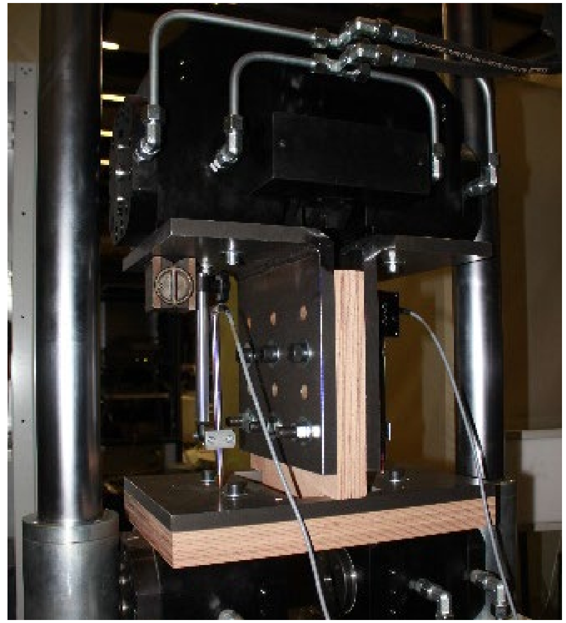
$$\text{Section Stiffness: } K_s(x) = \int_A a_s{}^T(y, z) \frac{d\sigma}{d\varepsilon} a_s(y, z) dA$$

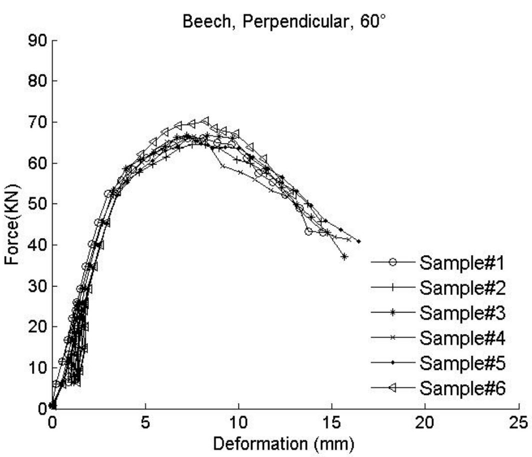


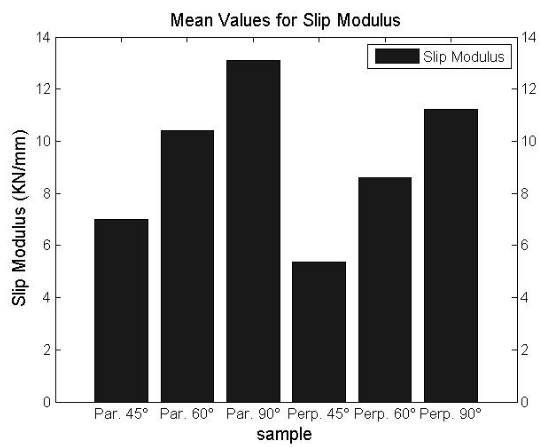


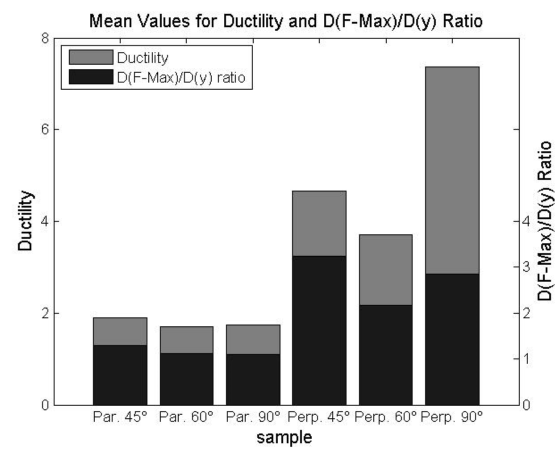
(a) (b)

Experimentals at connection scales



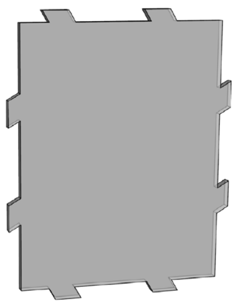




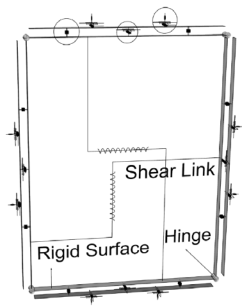


Macro Models vs. FE models

Applied Force

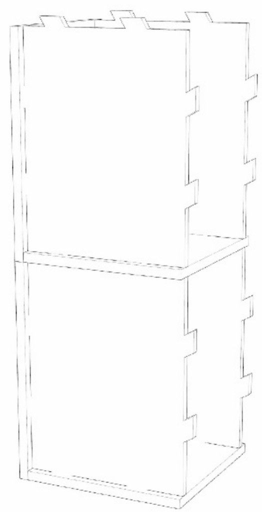


vs.

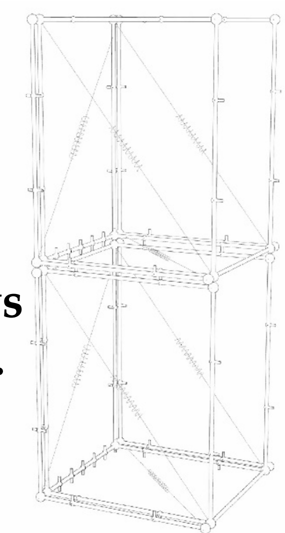


	Top Displacement (mm)	Base Reaction (KN)	Error	Run Time (sec.)
FE Model	3.0	46.22		190.90
Macro Model	3.0	46.002	≤ 0.5%	2.10

Applied Force



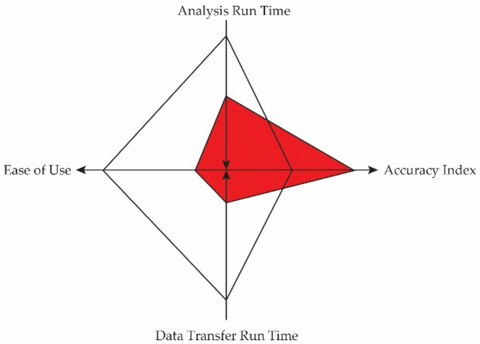
vs.

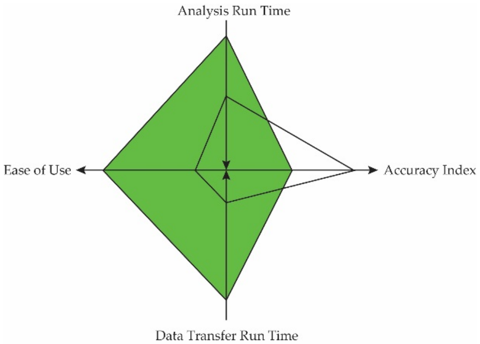


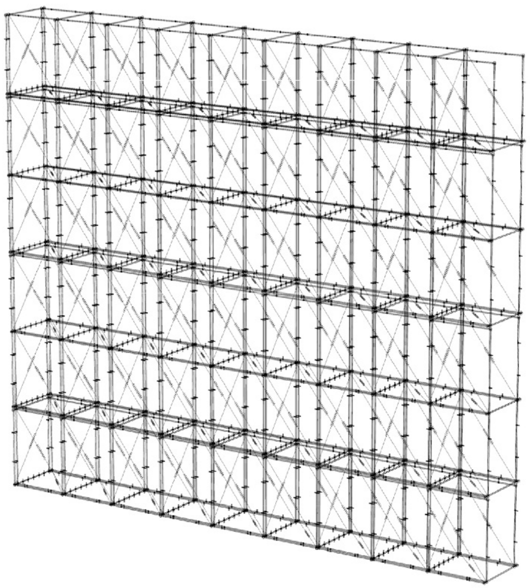
	Top Displacement (mm)	Base Reaction (KN)	Error	Run Time (sec.)
FE Model	3.0	45.78		240.60
Macro Model	3.0	46.00	≤ 0.48%	3.20

	Top Displacement (mm)	Base Reaction (KN)	Error	Run Time (sec.)
FE Model	1.5266	23.3		110.70
Macro Model	1.5195	23.3	≤ 0.46%	2.30

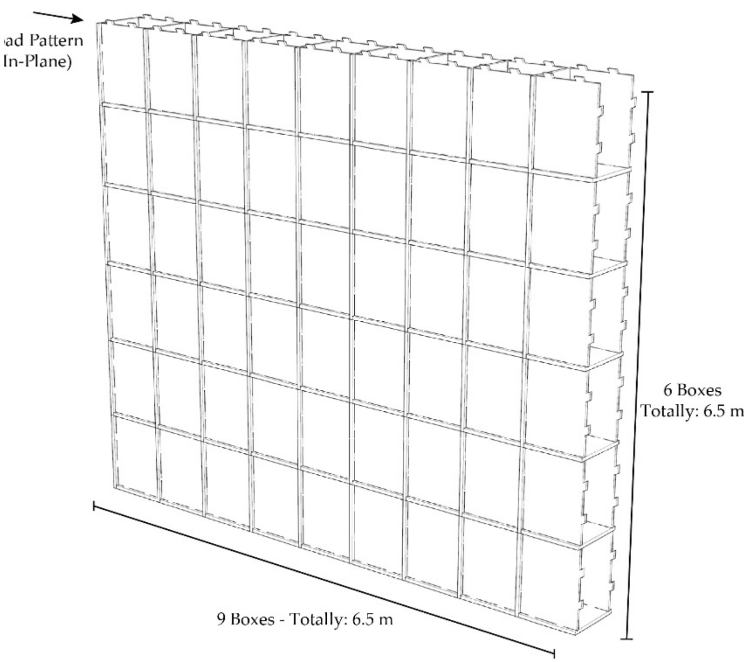
Fast-feedback real-time analysis







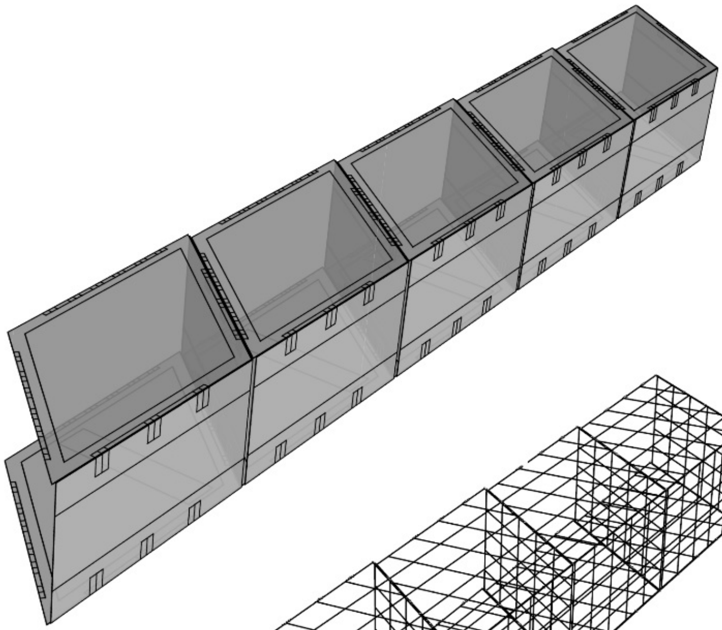
Macro Models

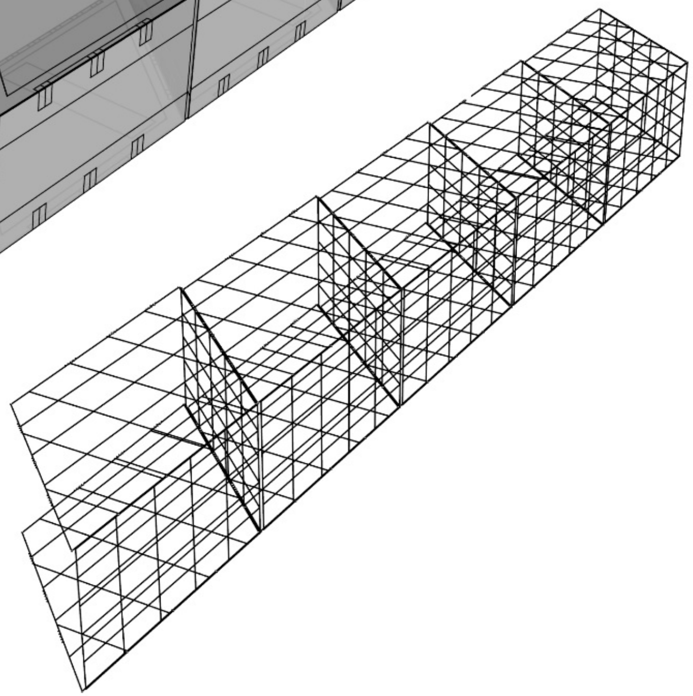


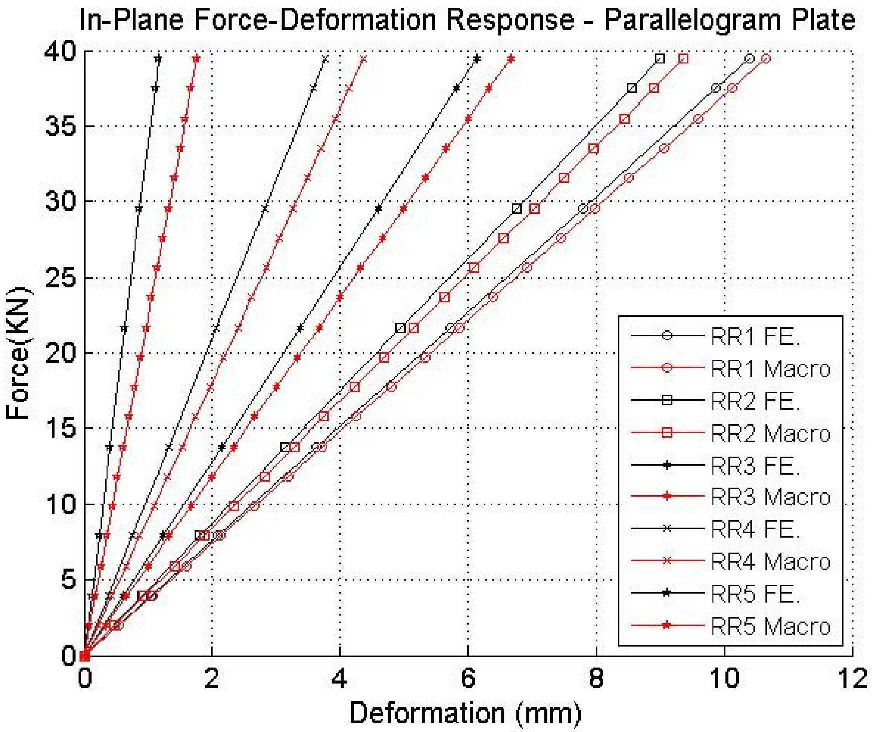
Geometry

Aryan Rezaei Rad

Research






In-Plane Force-Deformation Response - Parallelogram Plate
Force(KN)
Deformation (mm)
0
5
10
15
20
25
30
35
40
0
2
4
6
8
10
12
RR1 FE.
RR1 Macro
RR2 FE.
RR2 Macro
RR3 FE.
RR3 Macro
RR4 FE.
RR4 Macro
RR5 FE.
RR5 Macro

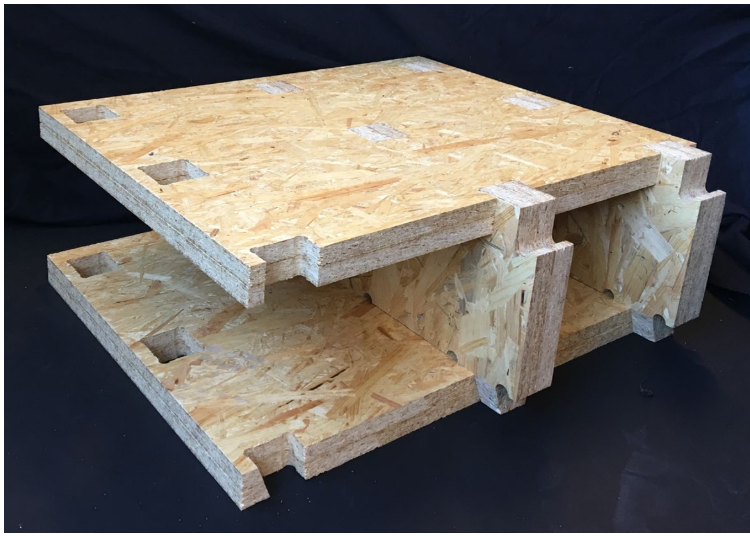
Outlook in future

Rhinoceros® 6

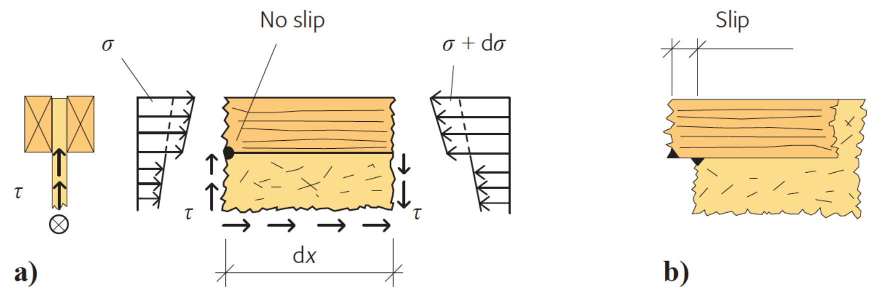
Microsoft® .NET

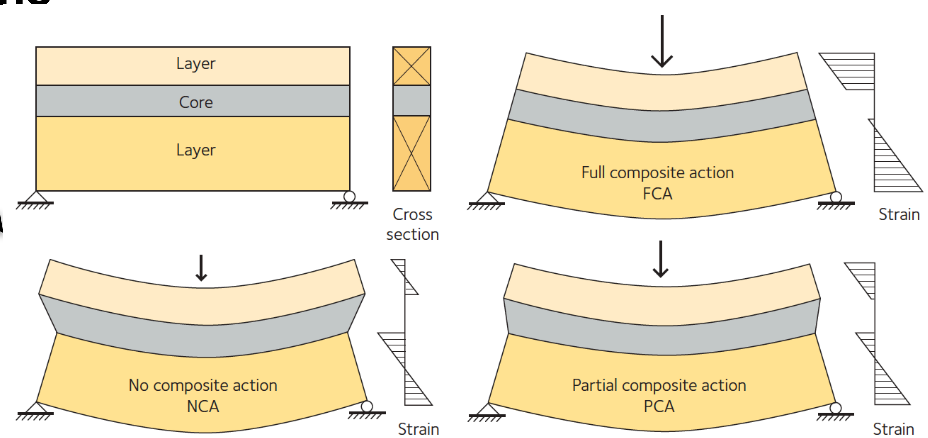
grasshopper
GENERATIVE MODELING FOR RHINO

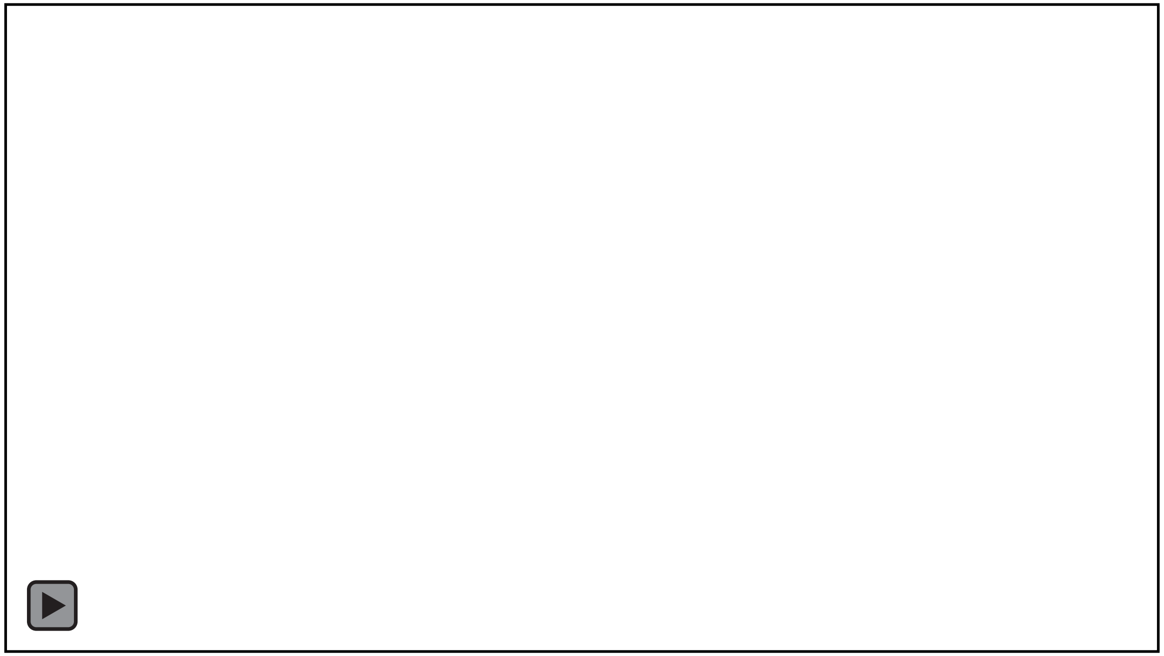
Professional Practice
Teaching
Previous Research & Completed projects
Current Research & Applied projects
Nabucco
Annen Project
MOBIC
Prefabricated timber structural elements using IMA
Centre d’Activité Grand Chalet
Liège Expo

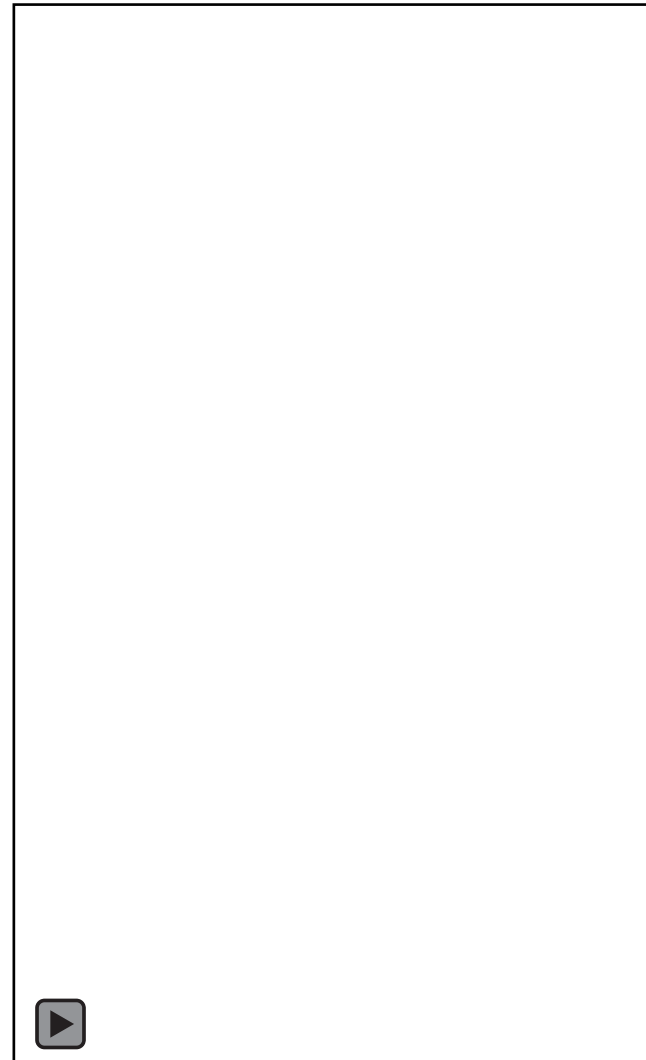


Composite Sections







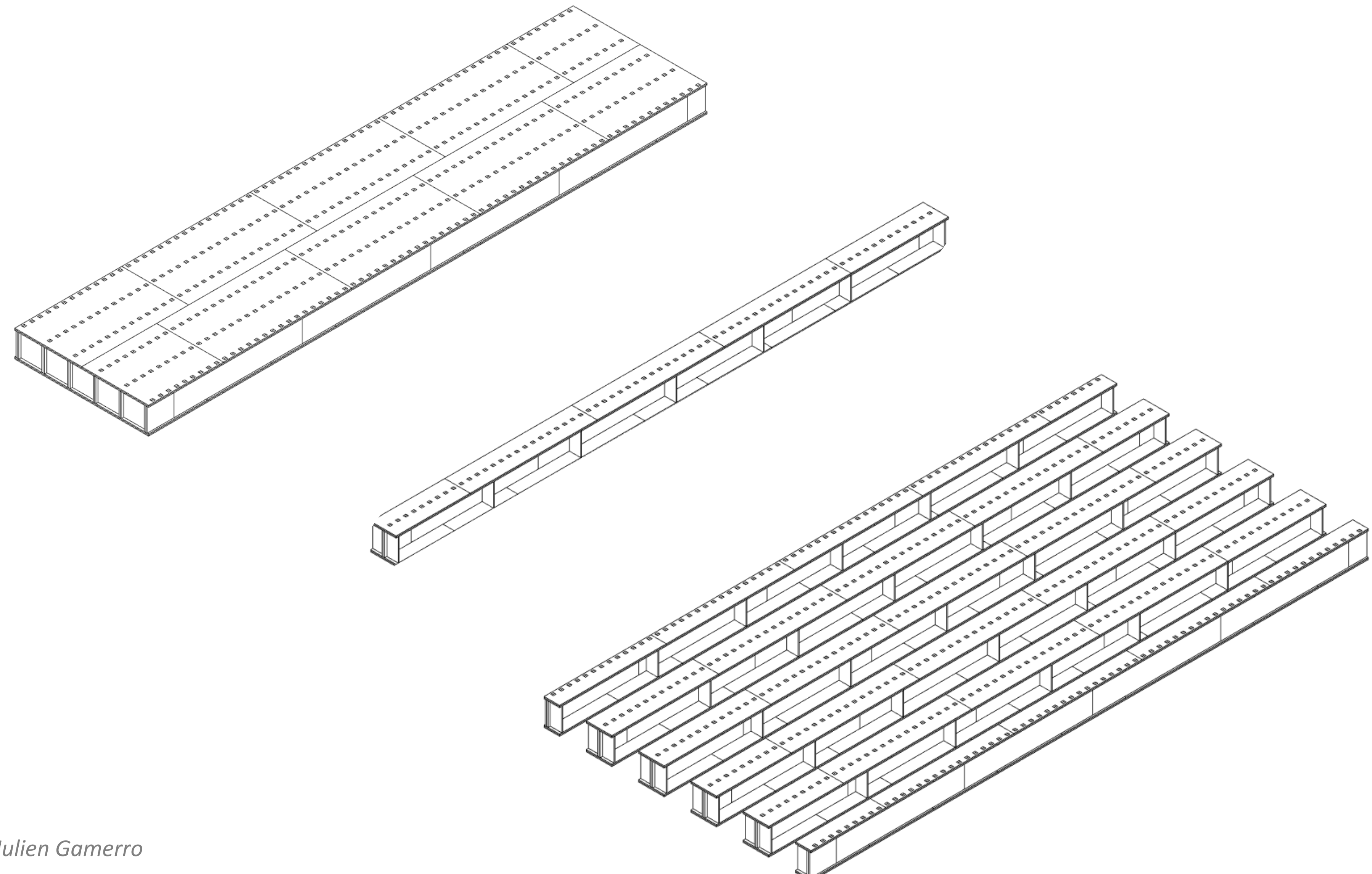


Continuous I-Beam

Parameters:

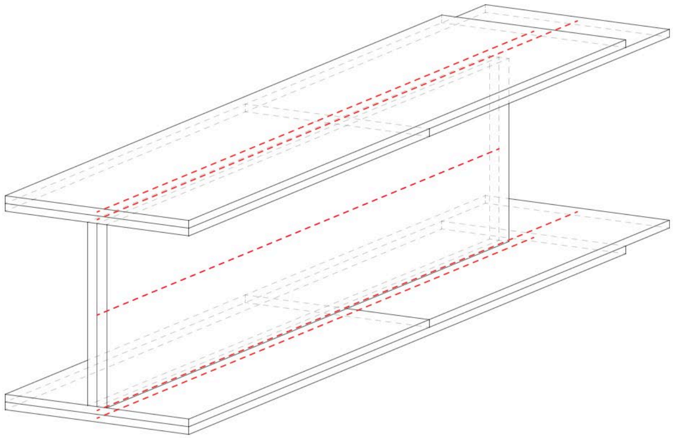
- Length : 2,5m
- Depth : 21 cm
- Width : 21 cm

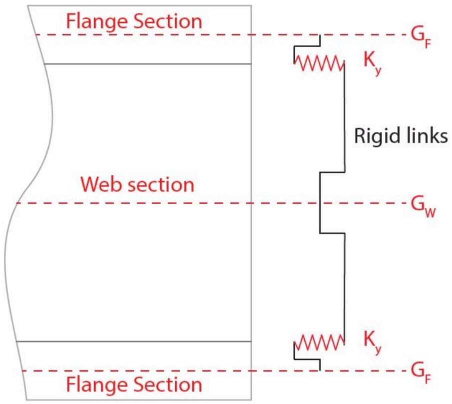
Division of elements



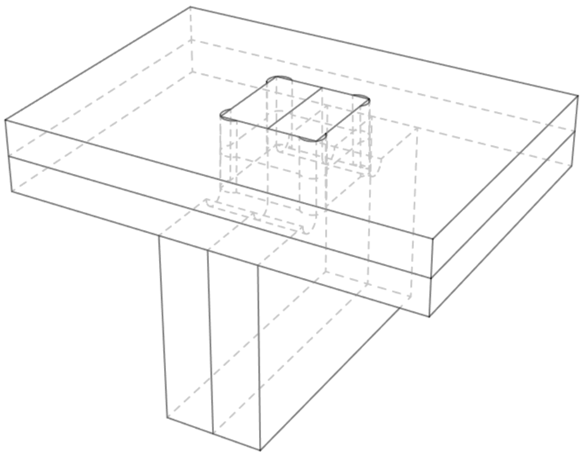
Julien Gamerro

Research

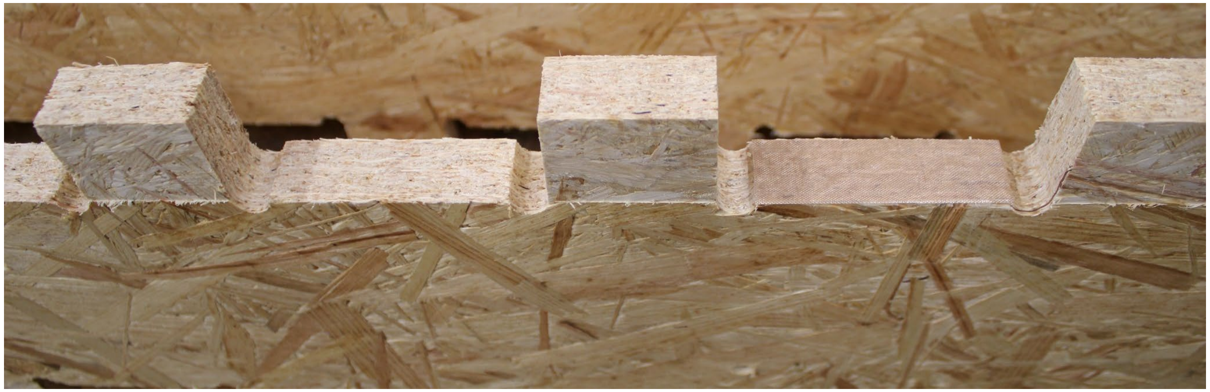




Embedment (kc) + Shear (ky)



Julien Gamerro



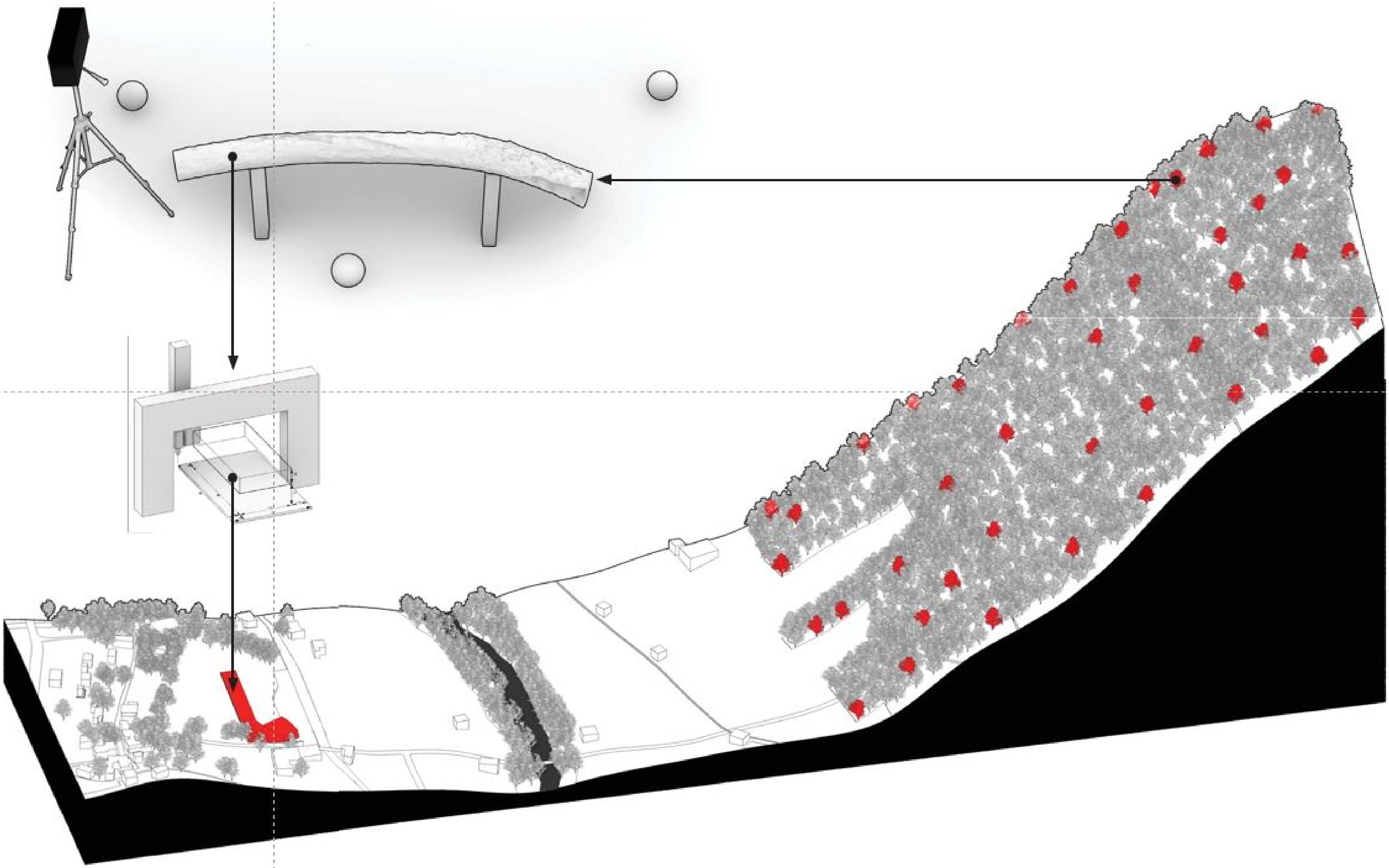
Julien Gamerro

Research

Julien Gamerro

Professional Practice
Teaching
Previous Research & Completed projects
Current Research & Applied projects
Nabucco
Annen Project
MOBIC
Centre d’Activité Grand Chalet
Woodworking joints and assembly methods for locally sawn timber elements in free-form structures
Liège Expo

Concept : collecting trees from mountains area



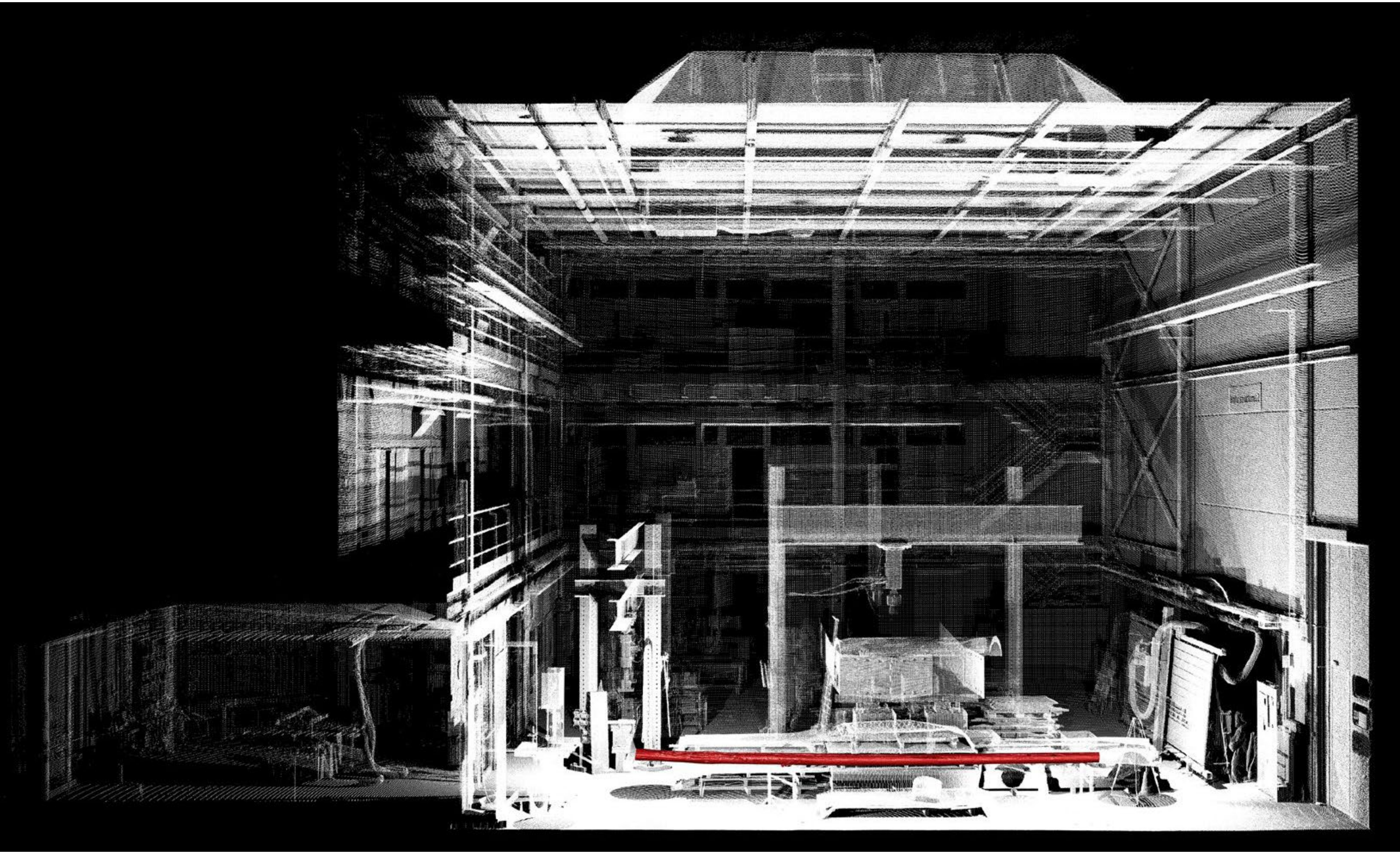
Petras Vestartas

Scanning trees

Petras Vestartas

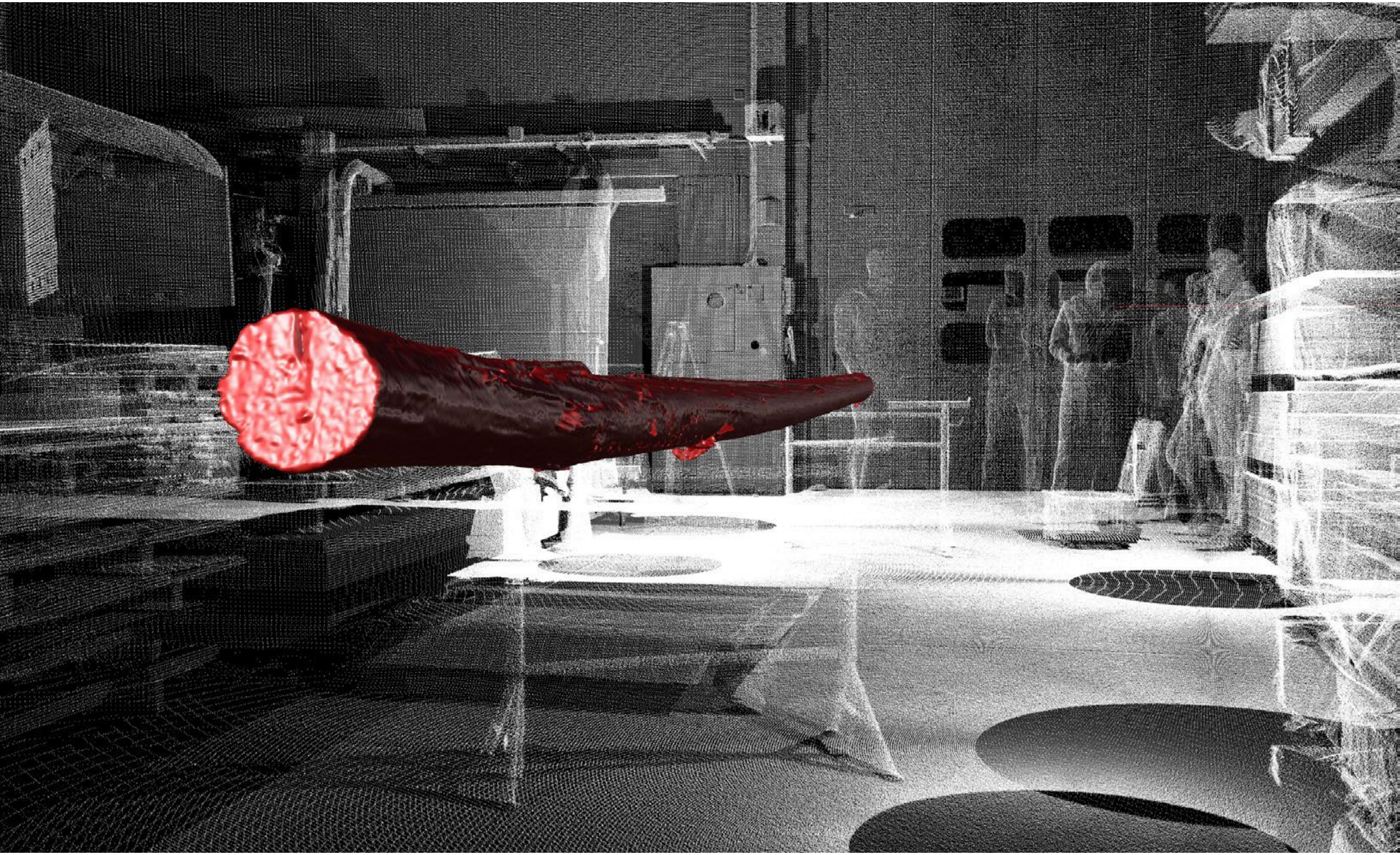
Research

Scanning trees

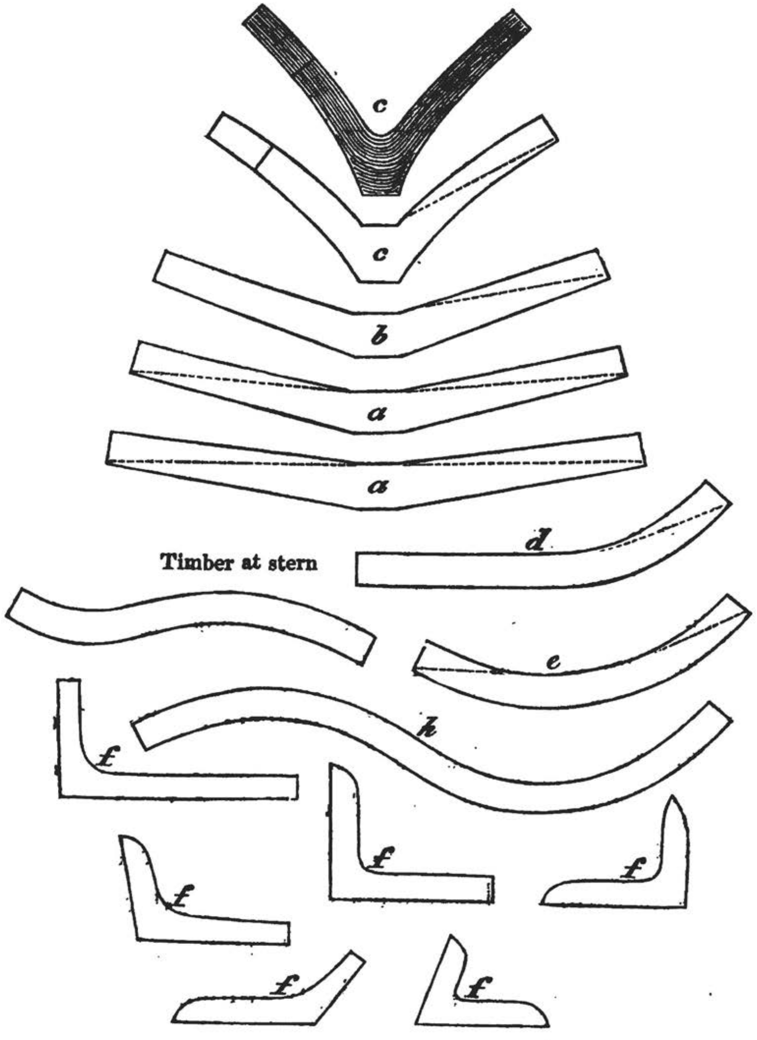


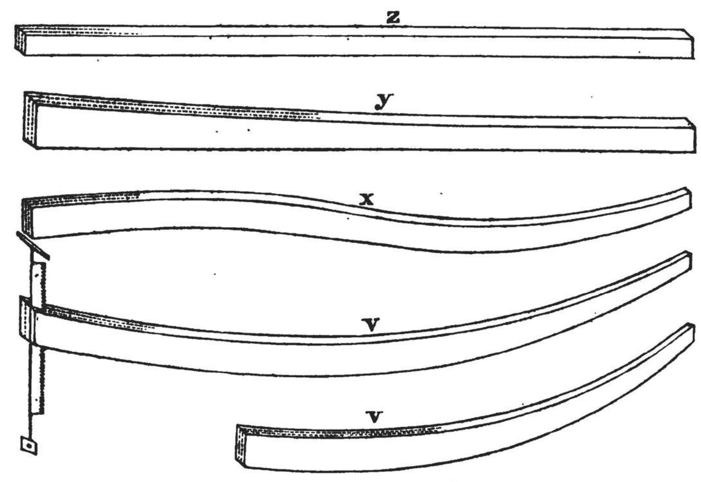
Petras Vestartas

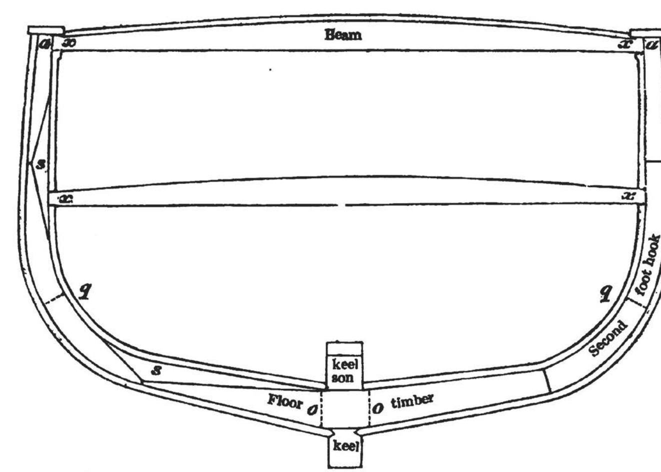
Scanning trees

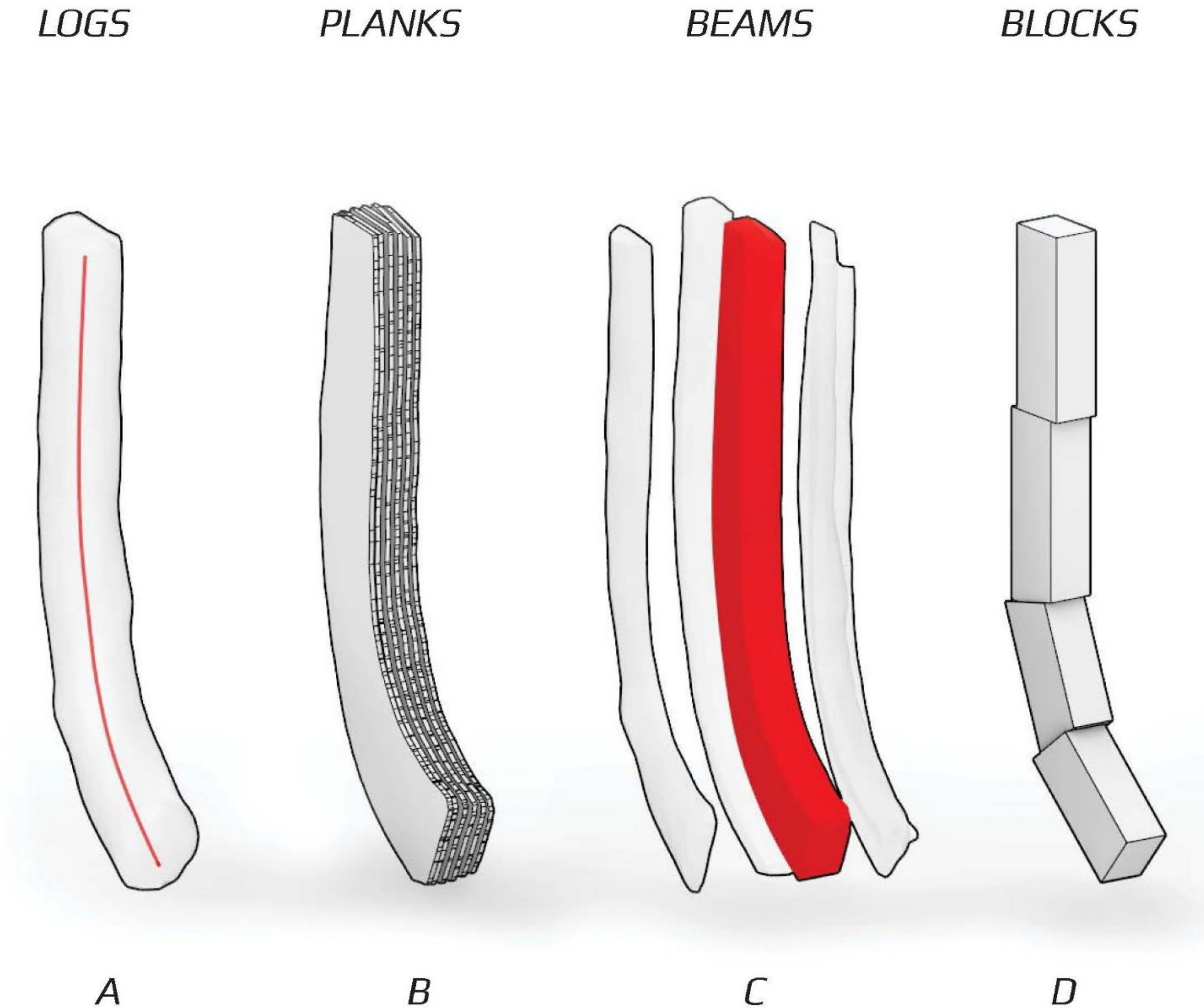


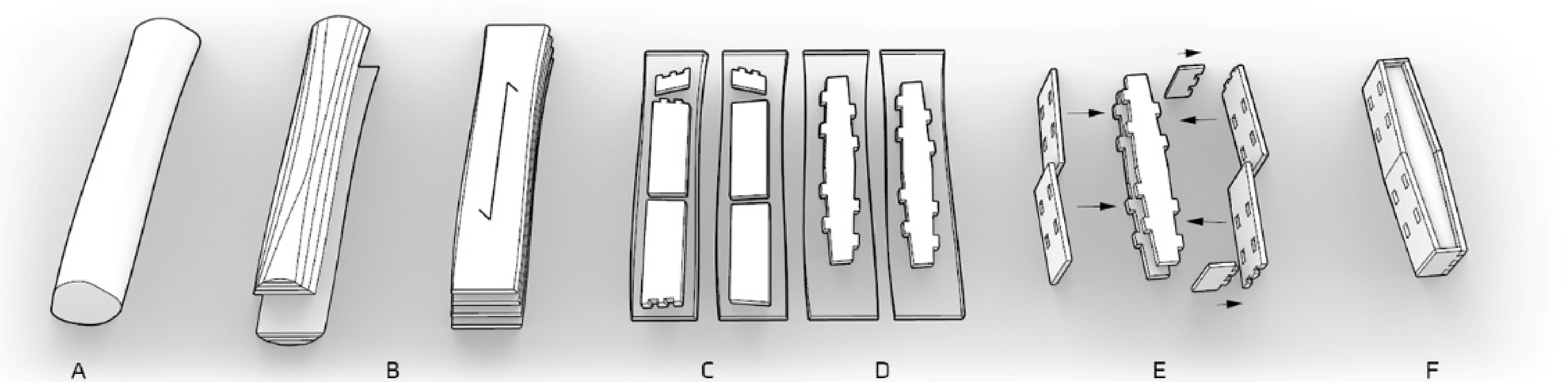
Petras Vestartas

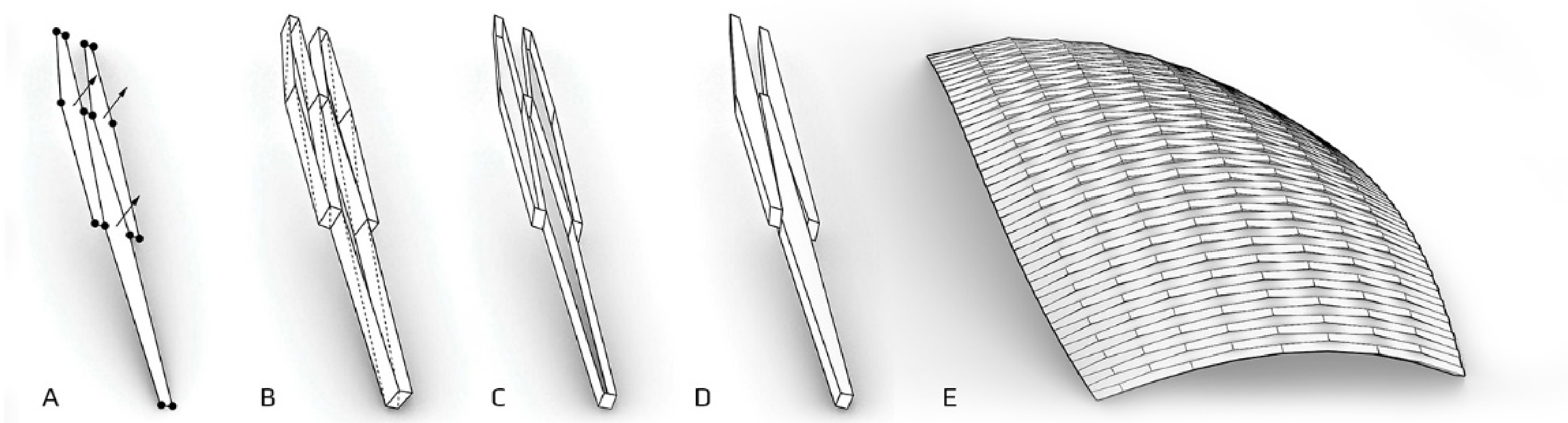

c
c
b
a
a
d
Timber at stern
e
h
f
f
f
f
f
f


z
y
x
v
v


Beam
a
x
x
a
s
x
x
q
q
foot hook
Second
keel
son
s
Floor
o
o
timber
keel


LOGS
PLANKS
BEAMS
BLOCKS
A
B
C
D





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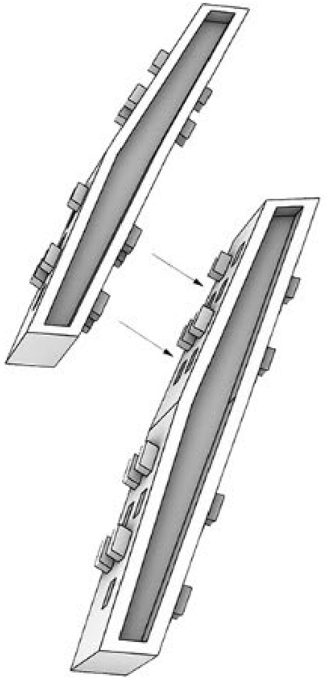
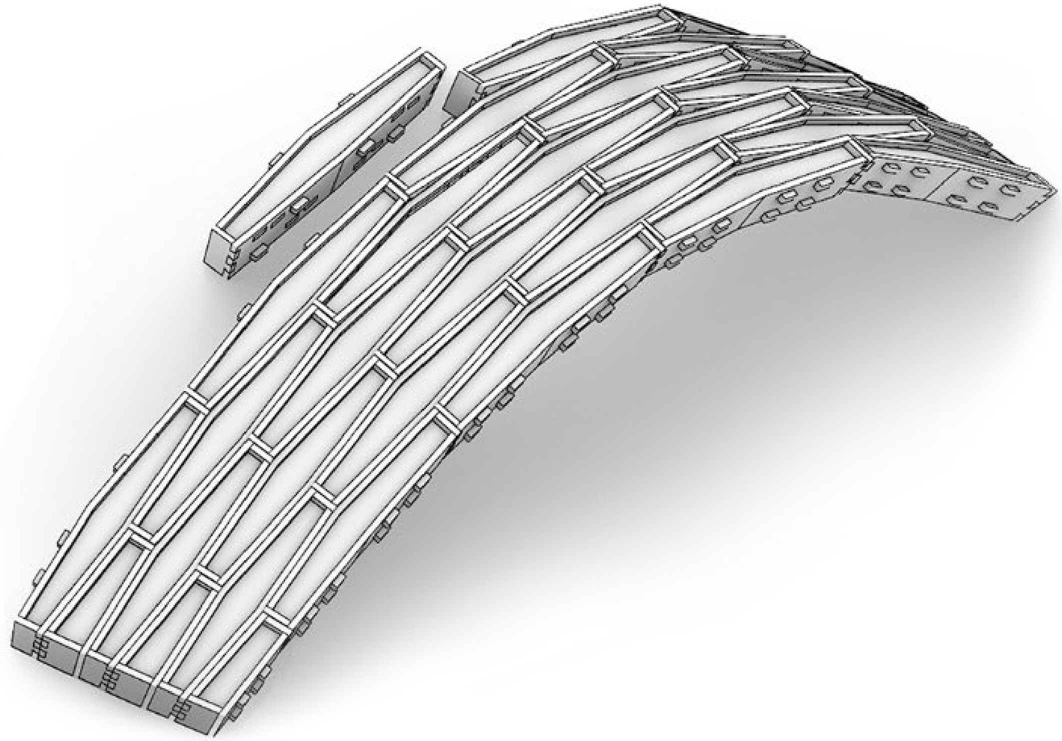
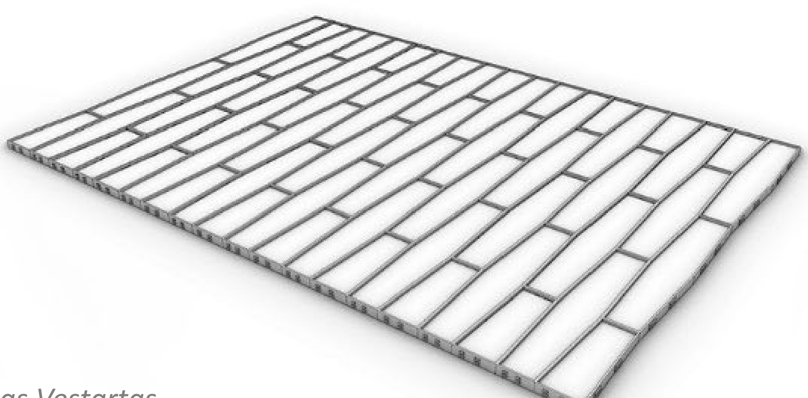
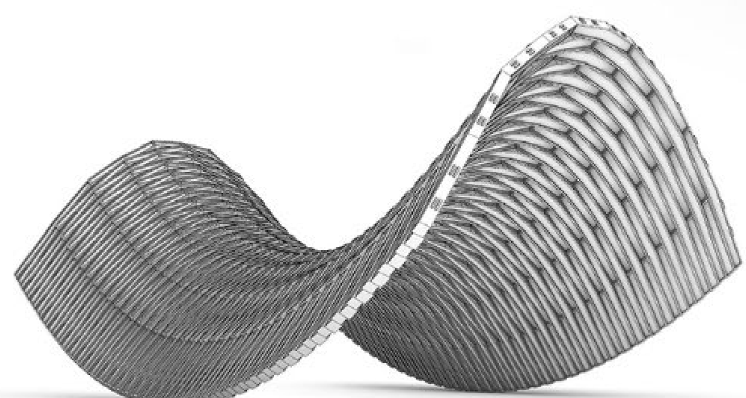
Assemblies sequences









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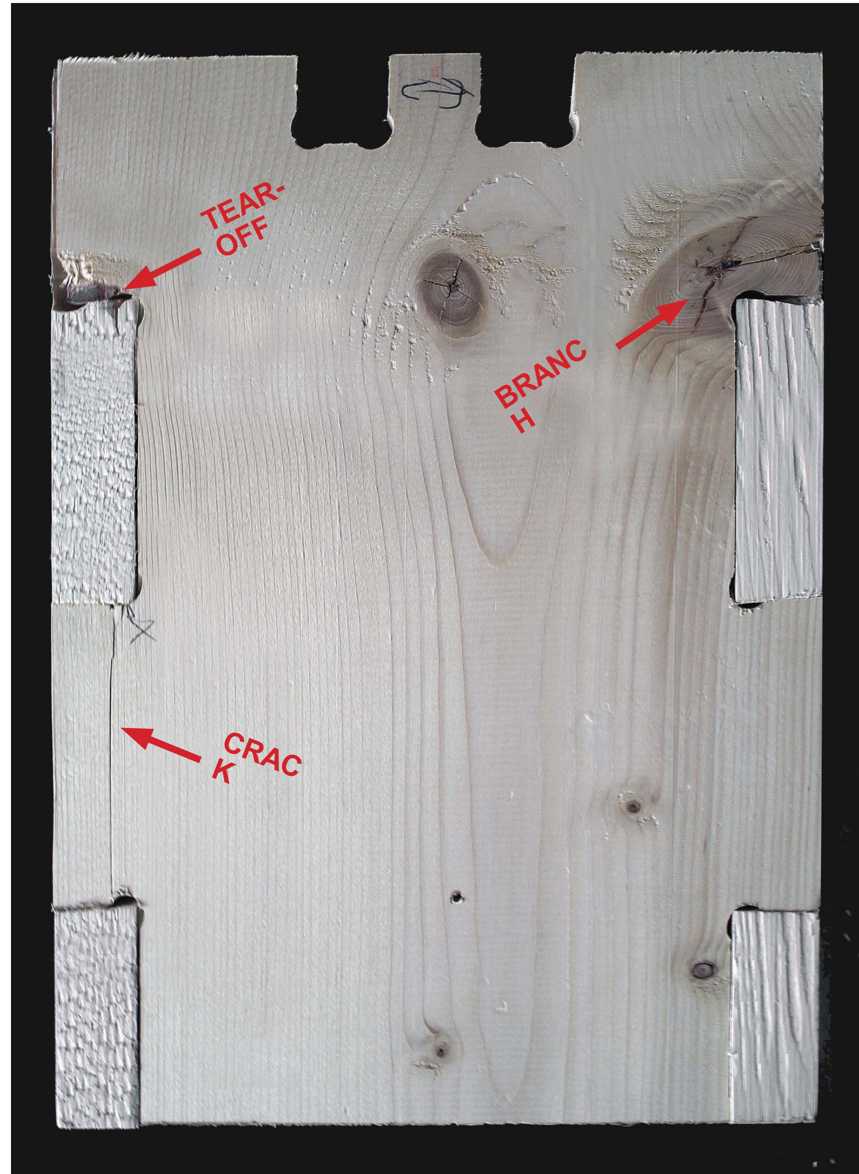
Research

Prototype 1 – Edge Joints



Prototype 2 Through Tenon Joint

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Prototype

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Prototype

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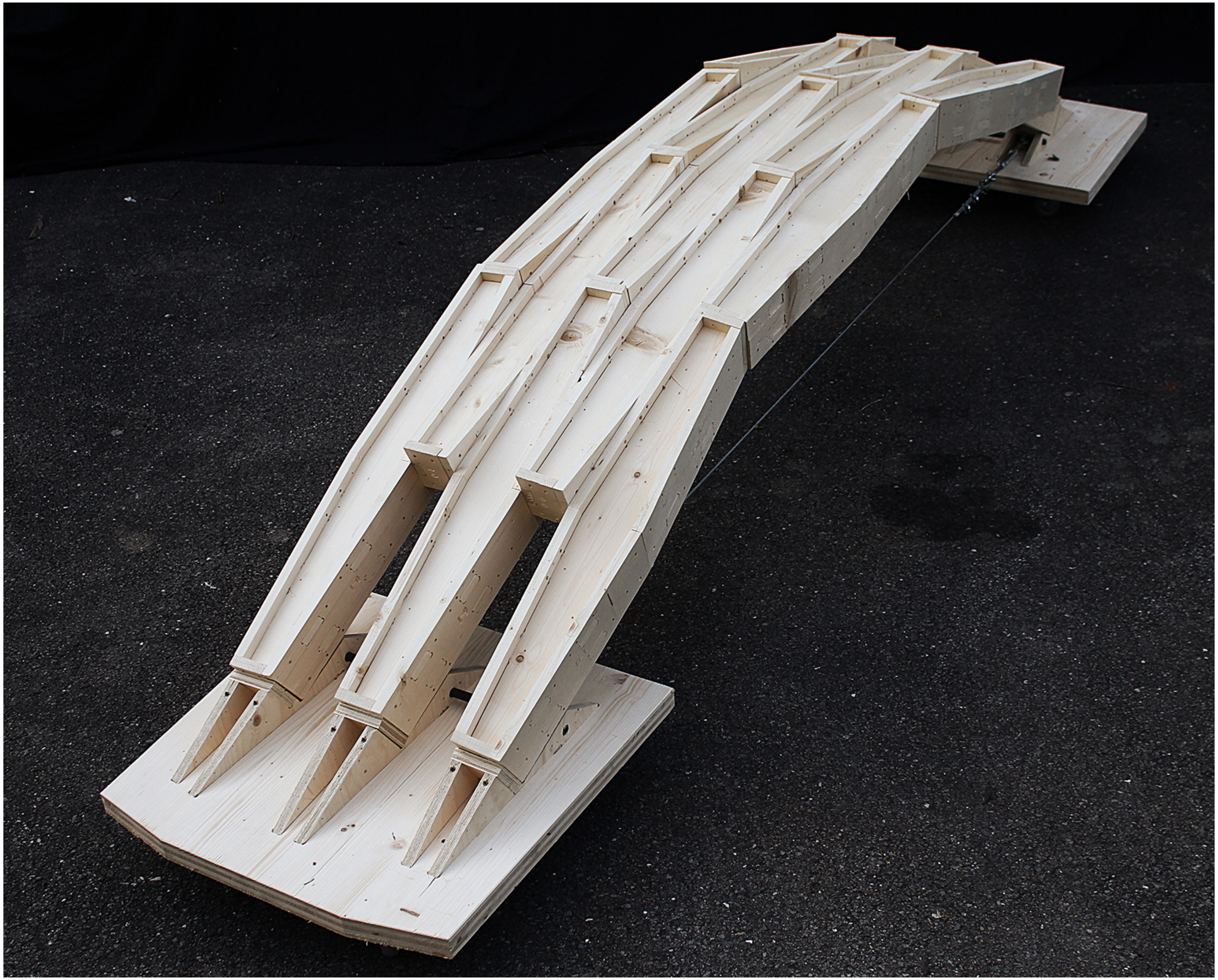
Prototype



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Research

Round Tree Speciment

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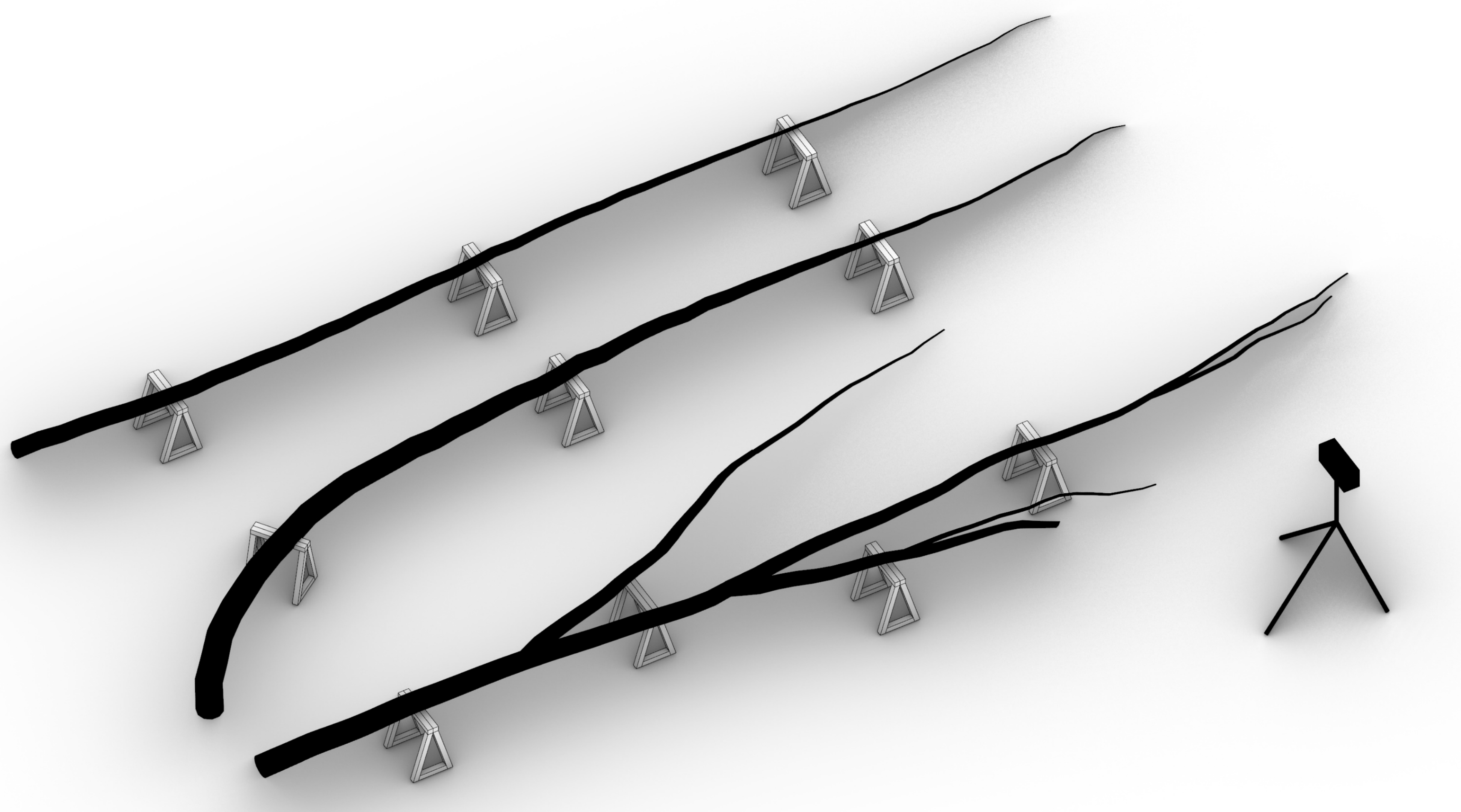
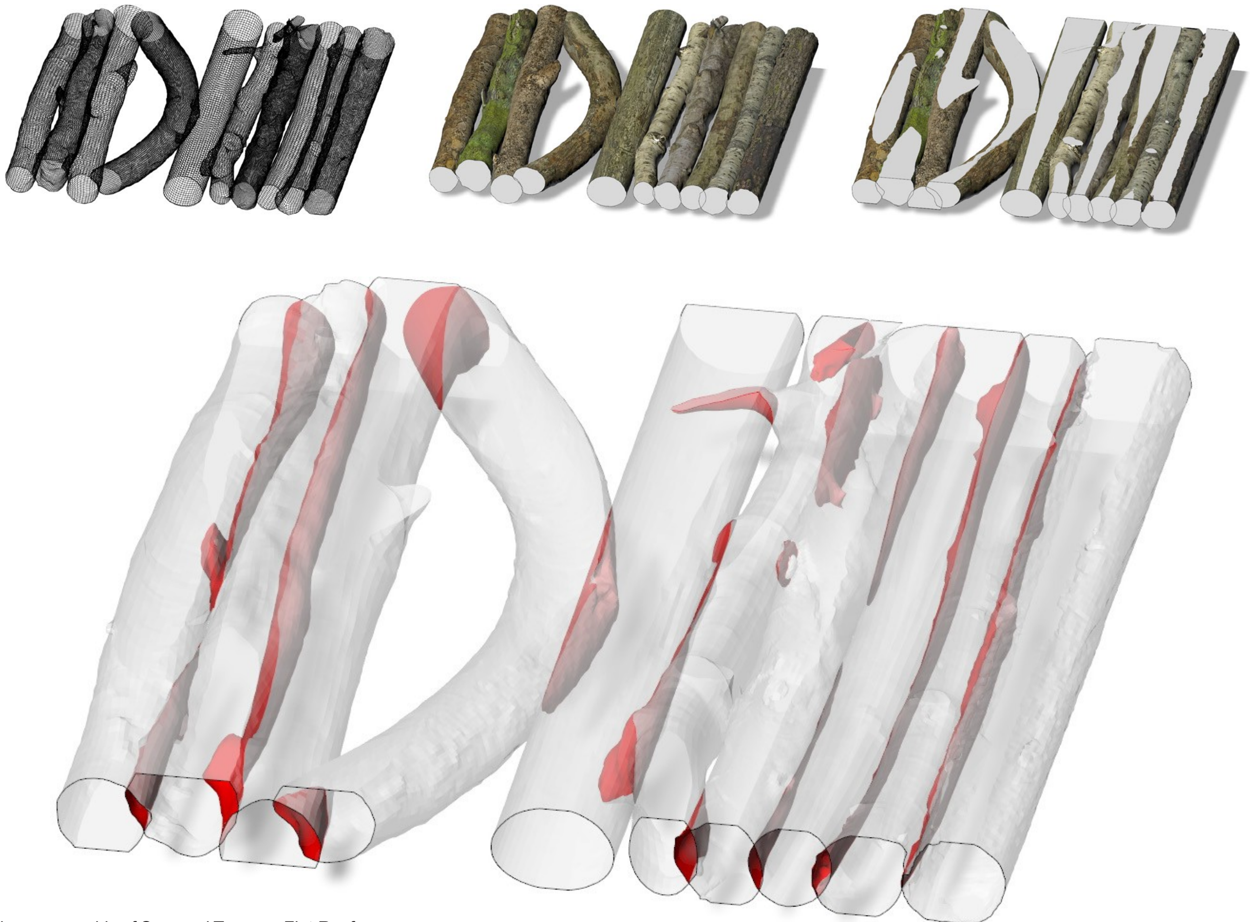
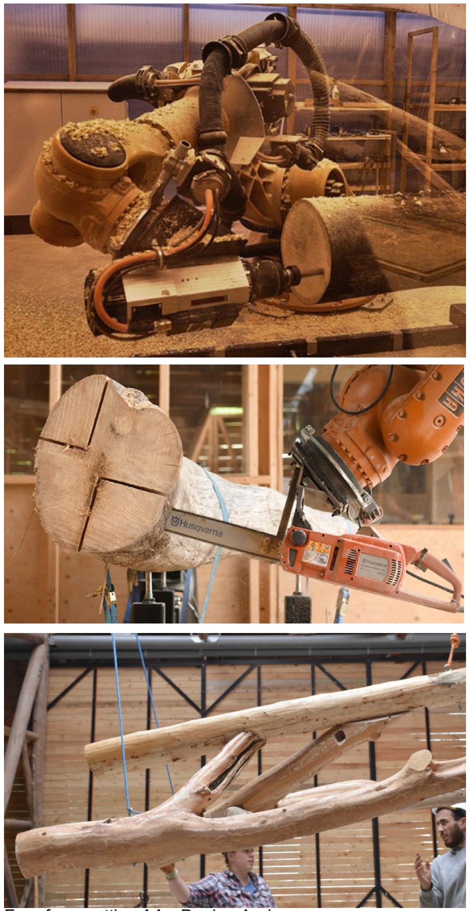


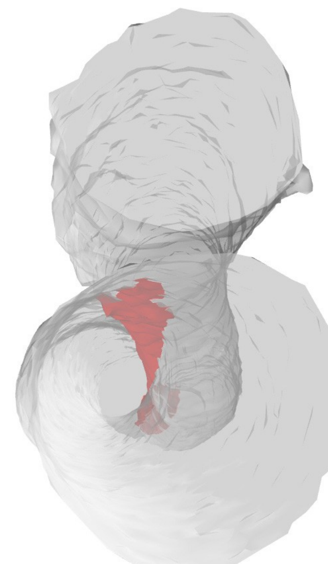


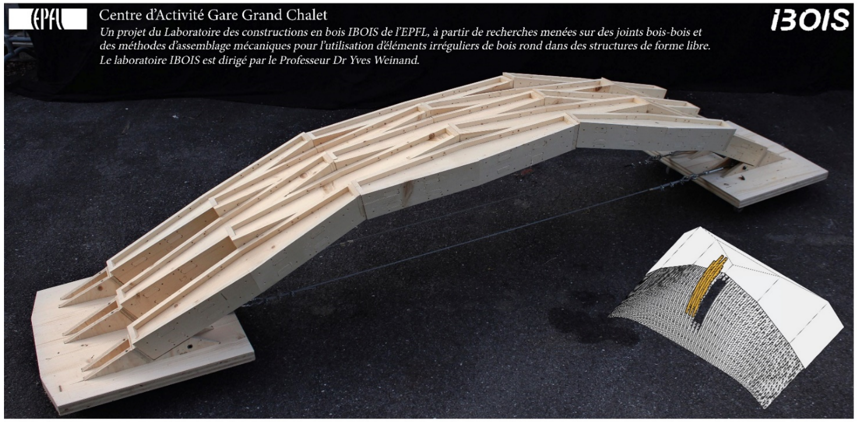
Linear assembly of Scanned Trees as Flat Roof
Structure



Free form cutting AA - Design And Make

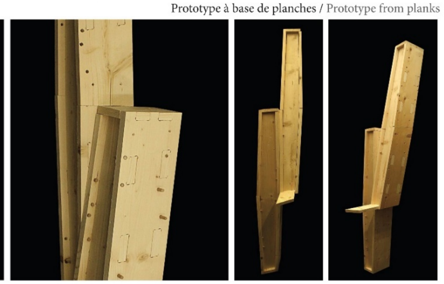
Scanned trees are intersected. Intersected area has to be cut out.





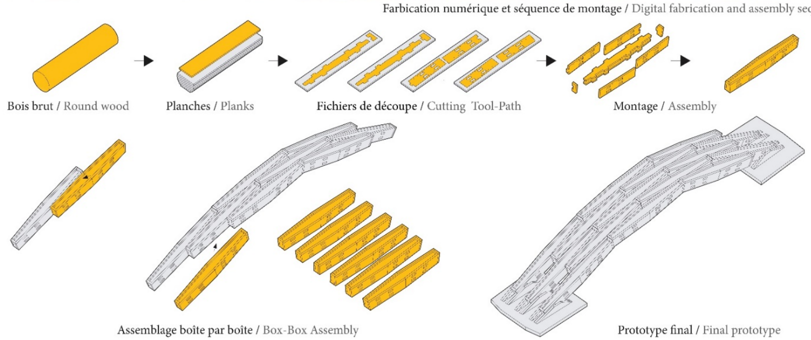
Prototype à base de planches / Prototype from planks

Tenon et mortaise / Through-tenon joint



Joint enturé / Finger joint with dowels

Farbication numérique et séquence de montage / Digital fabrication and assembly sequence

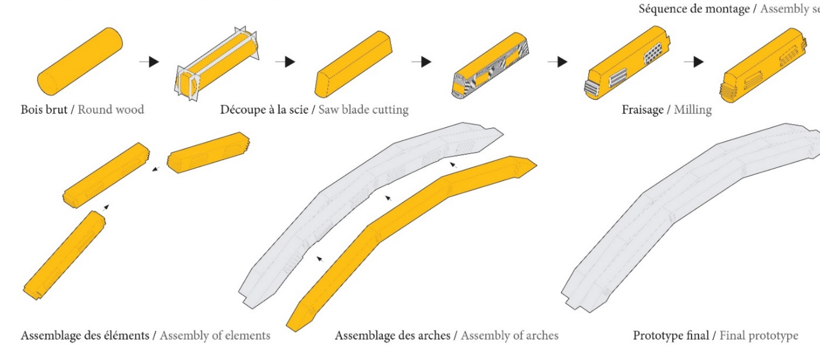


Prototype à base de bois brut / Prototype from round

Farbication numérique 4,5 axe CNC / Digital fabrication 4,5 axis CNC

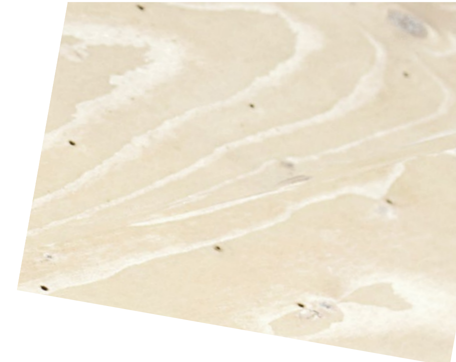
Finger joint / Finger joint

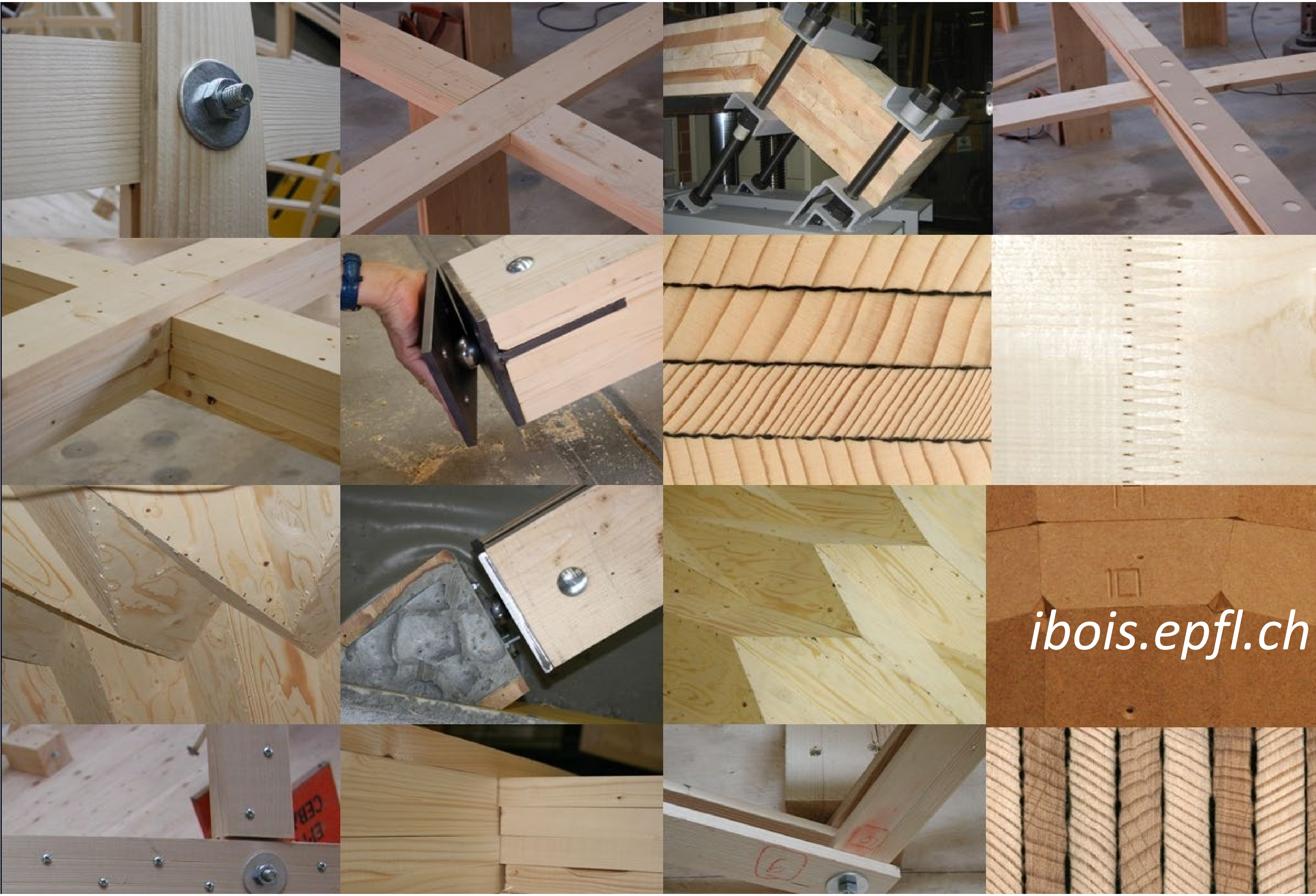
Séquence de montage / Assembly sequence



Project

BIRKHÄUSER

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