Laboratory for Timber Constructions

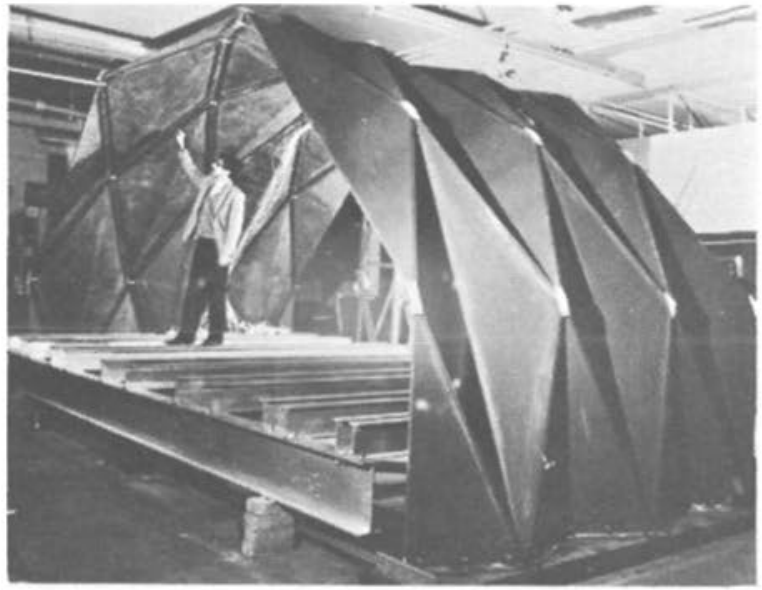
Architecture: conception et développement du projet de Vidy

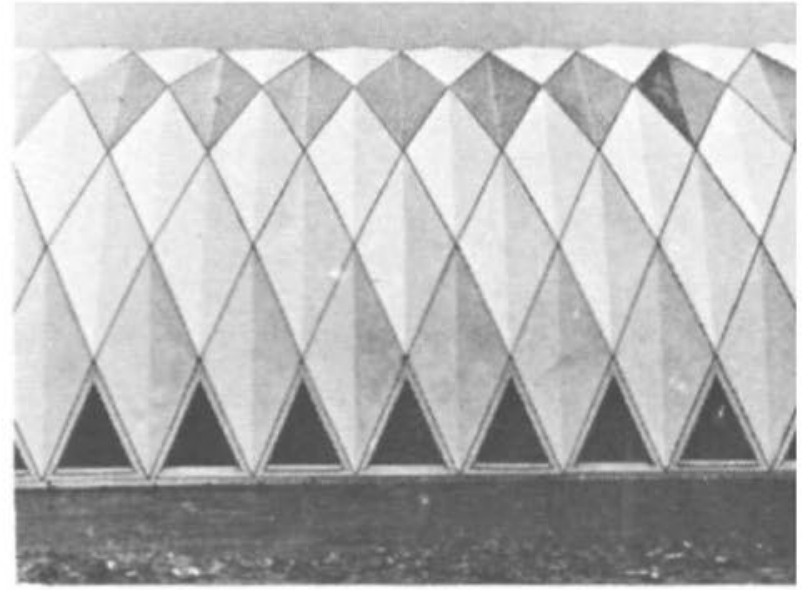
Yves Weinand | Professor

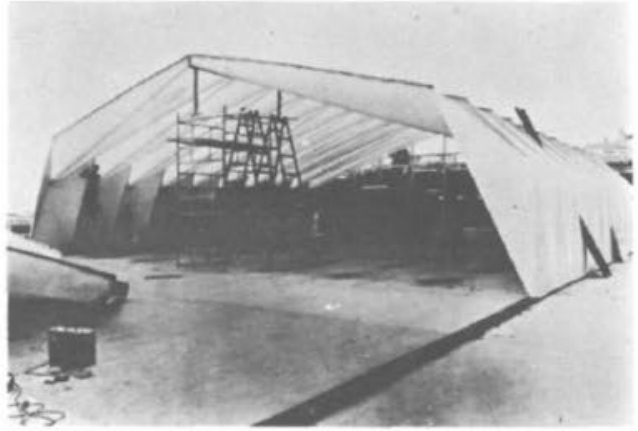
IBOIS | EPFL | Lausanne

IBOIS EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Zylindergewölbe-Faltwerke

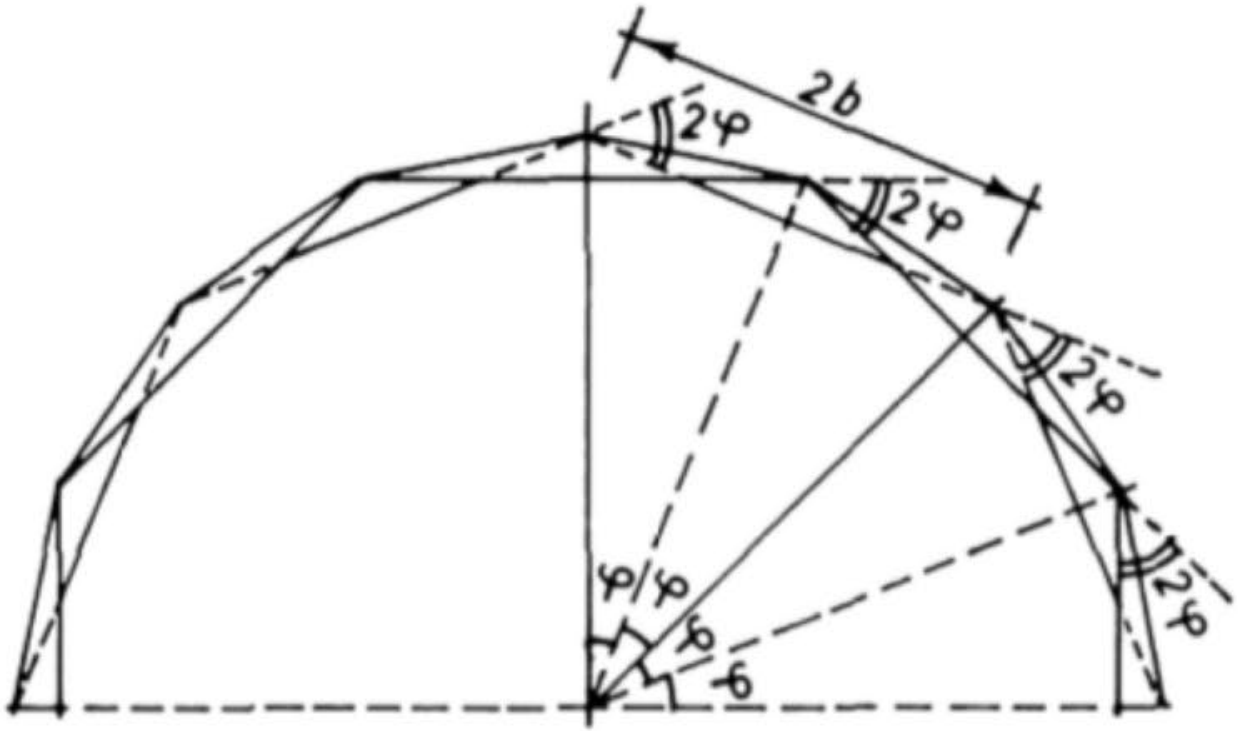


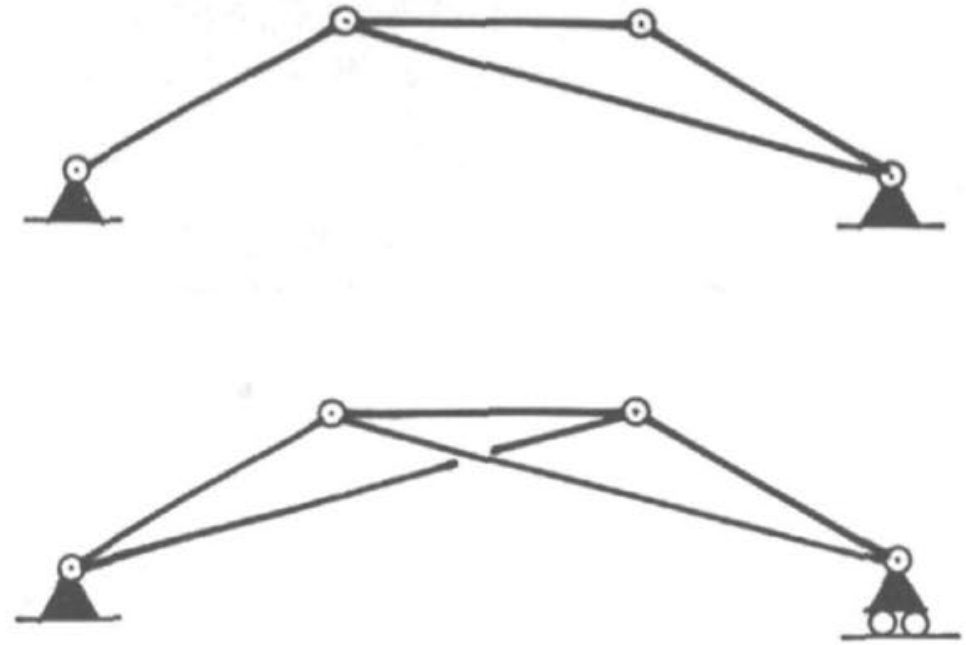




1. Makowski, Z., 2.,3.,7. Renzo Piano Sulfur Factory 4. Temporary Accommodation for Farmworkers, CA USA, 5. Swimming Pool, Lincoln, UK 6. Huybers, P.

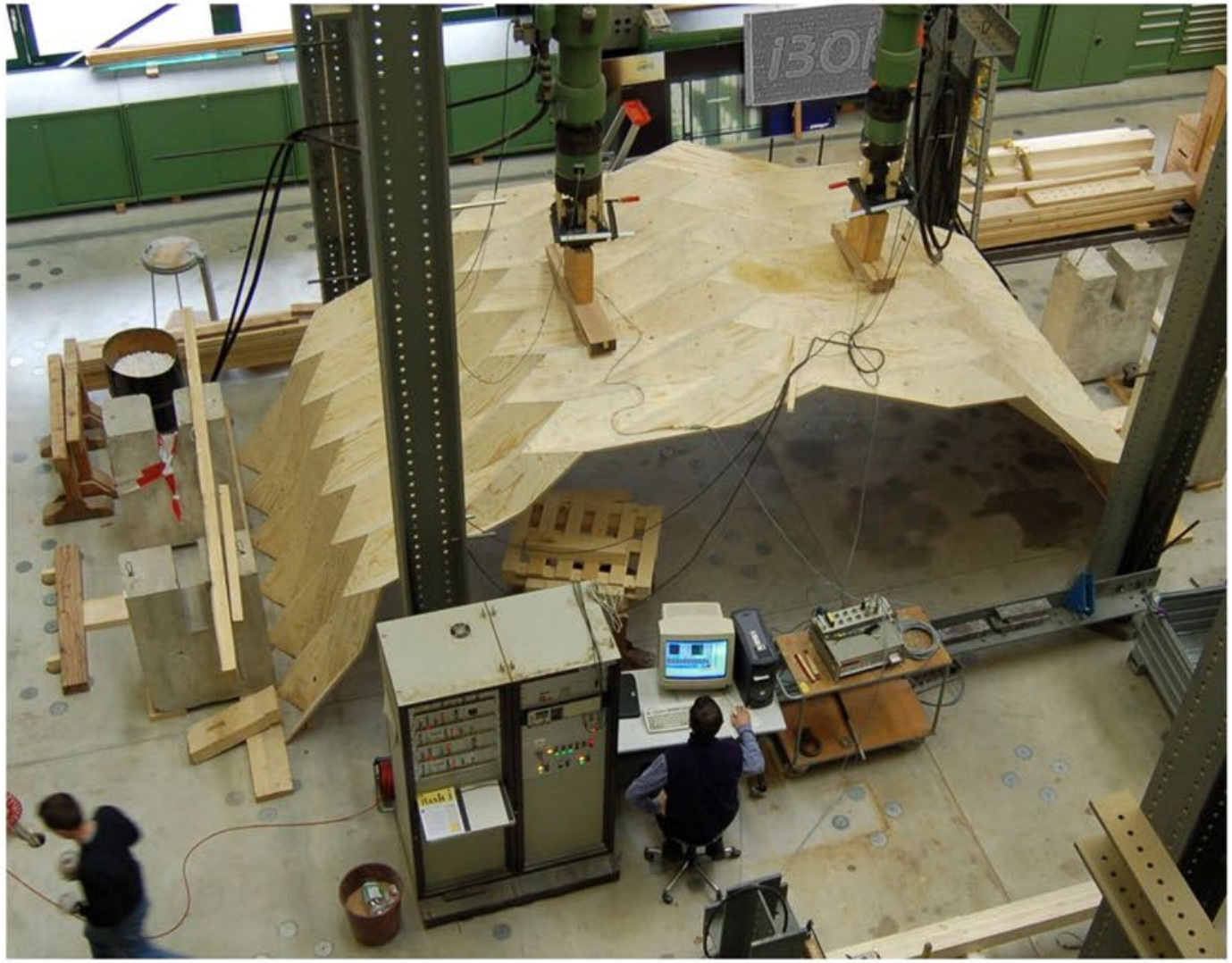
Antiprismatische Faltwerksgeometrie

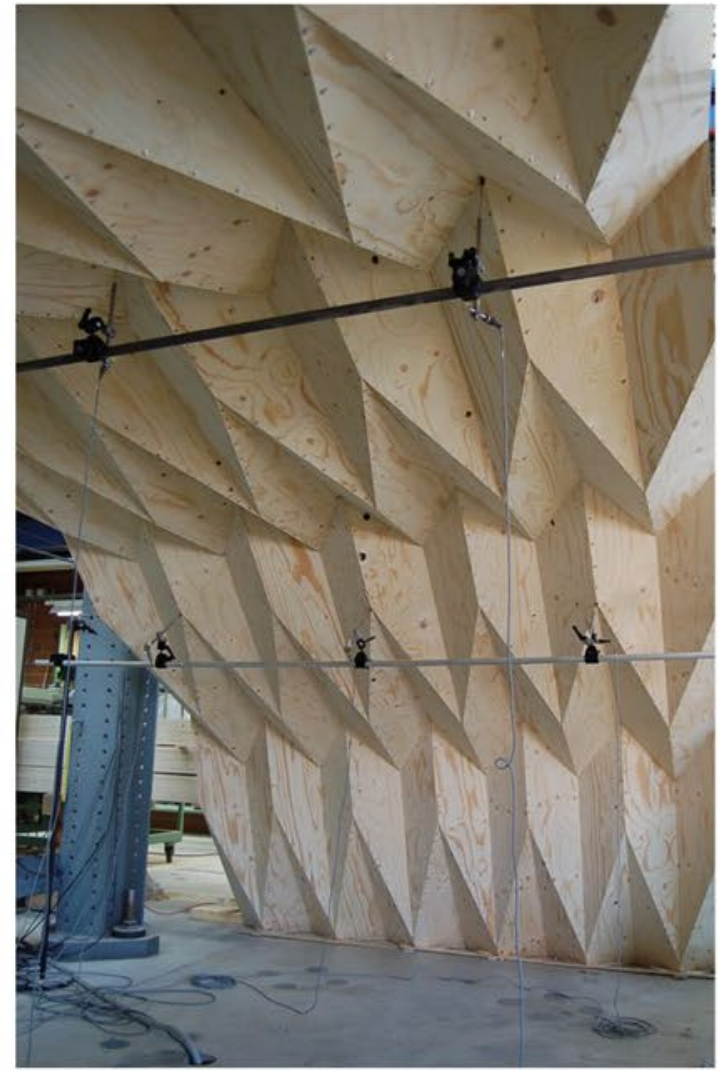




Huybers, P. *See-through Structuring - A Method of constructions for large span plastics roofs*, 1972

Zylindergewölbe-Faltwerk aus Holzplatten, 2006





Buri, H. *Origami Folded Plate Structures*, 2006-2010

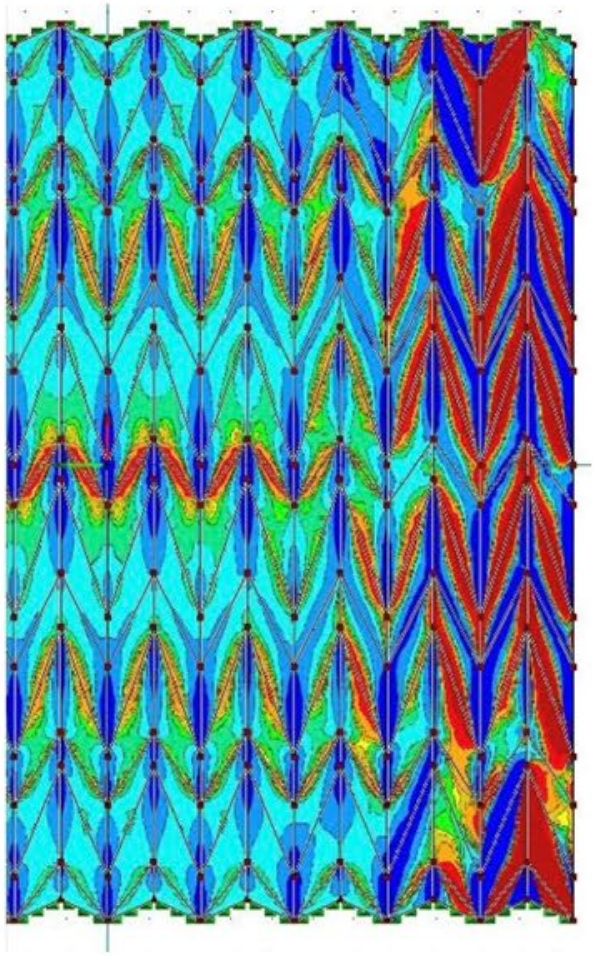
Faltwerk aus Holzplatten, 2006

Buri, H. *Origami Folded Plate Structures*, 2006-2010

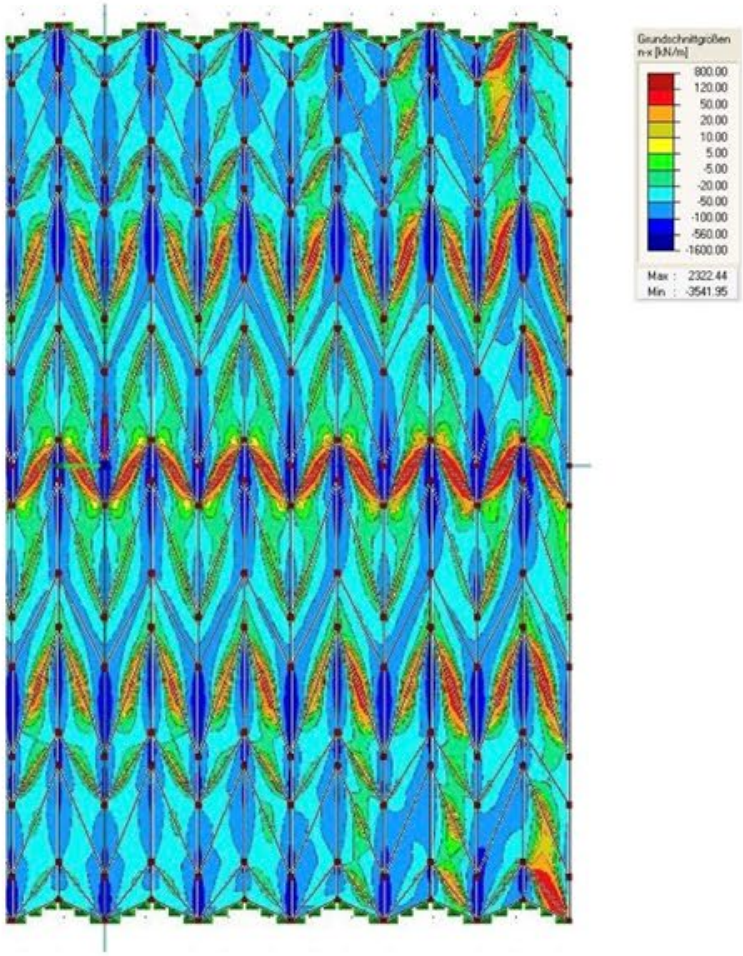
Analyse Faltwerk aus Holzplatten, 2009

Buri, H. *Origami Folded Plate Structures*, 2006-2010

Gelenkige Verbindungen

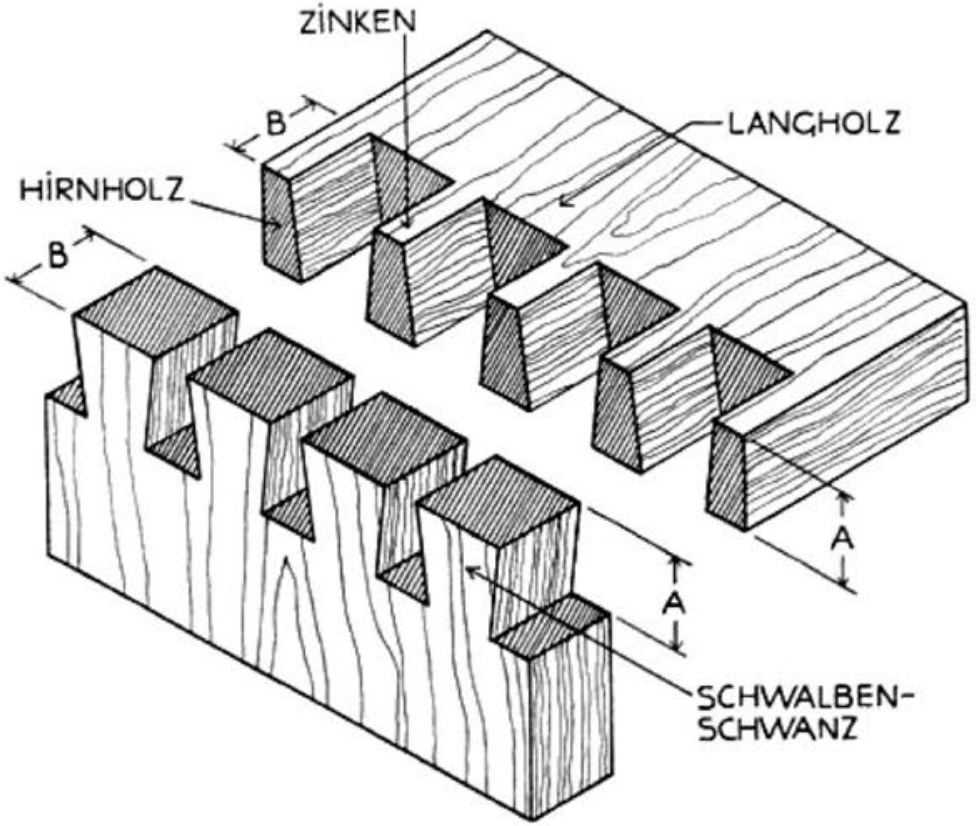


Starre Verbindungen



Hahn, B. *Analyse eines räumlichen Tragwerks aus Brettsperrholz*, 2009

Inspiration Tischlerhandwerk



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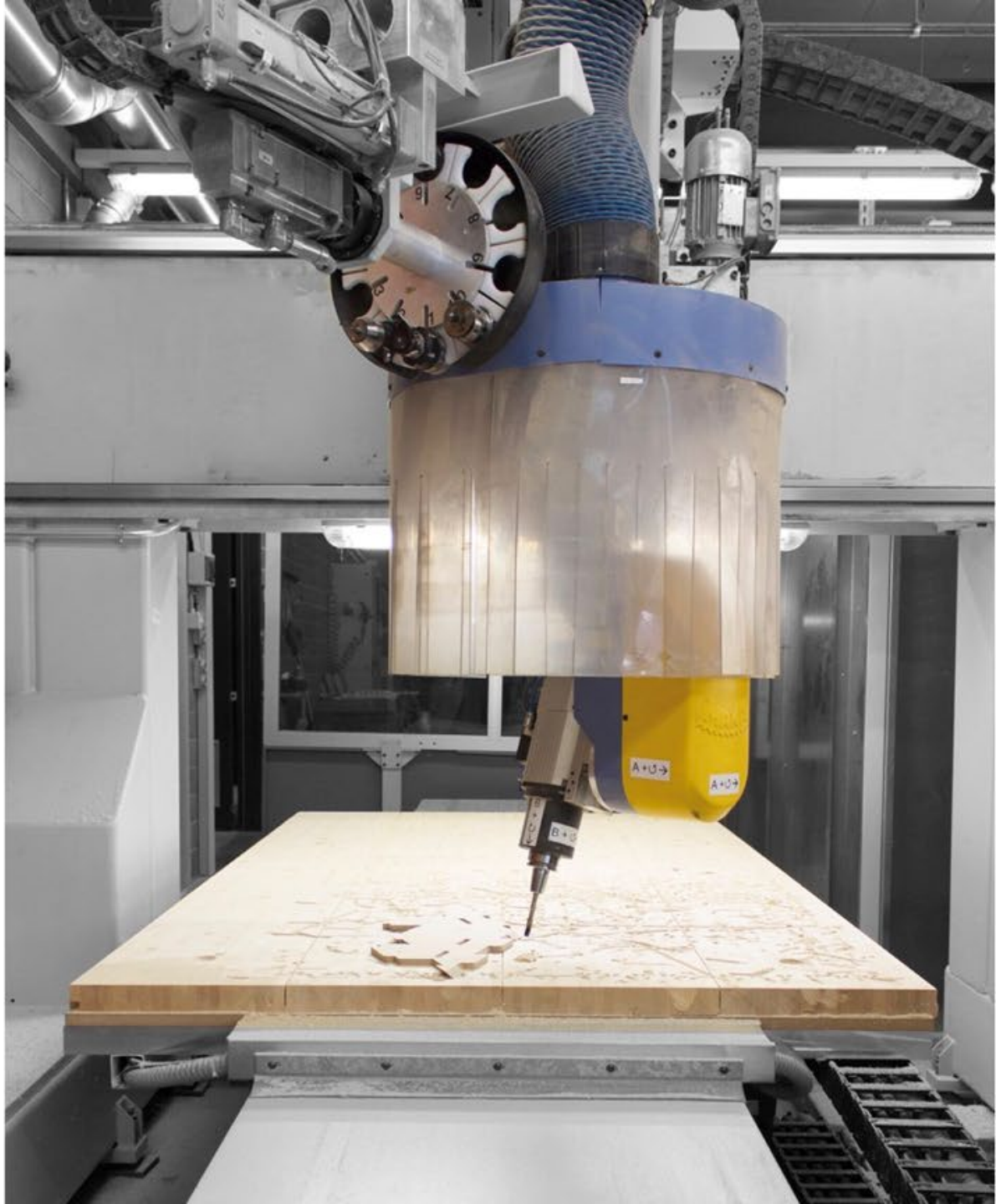
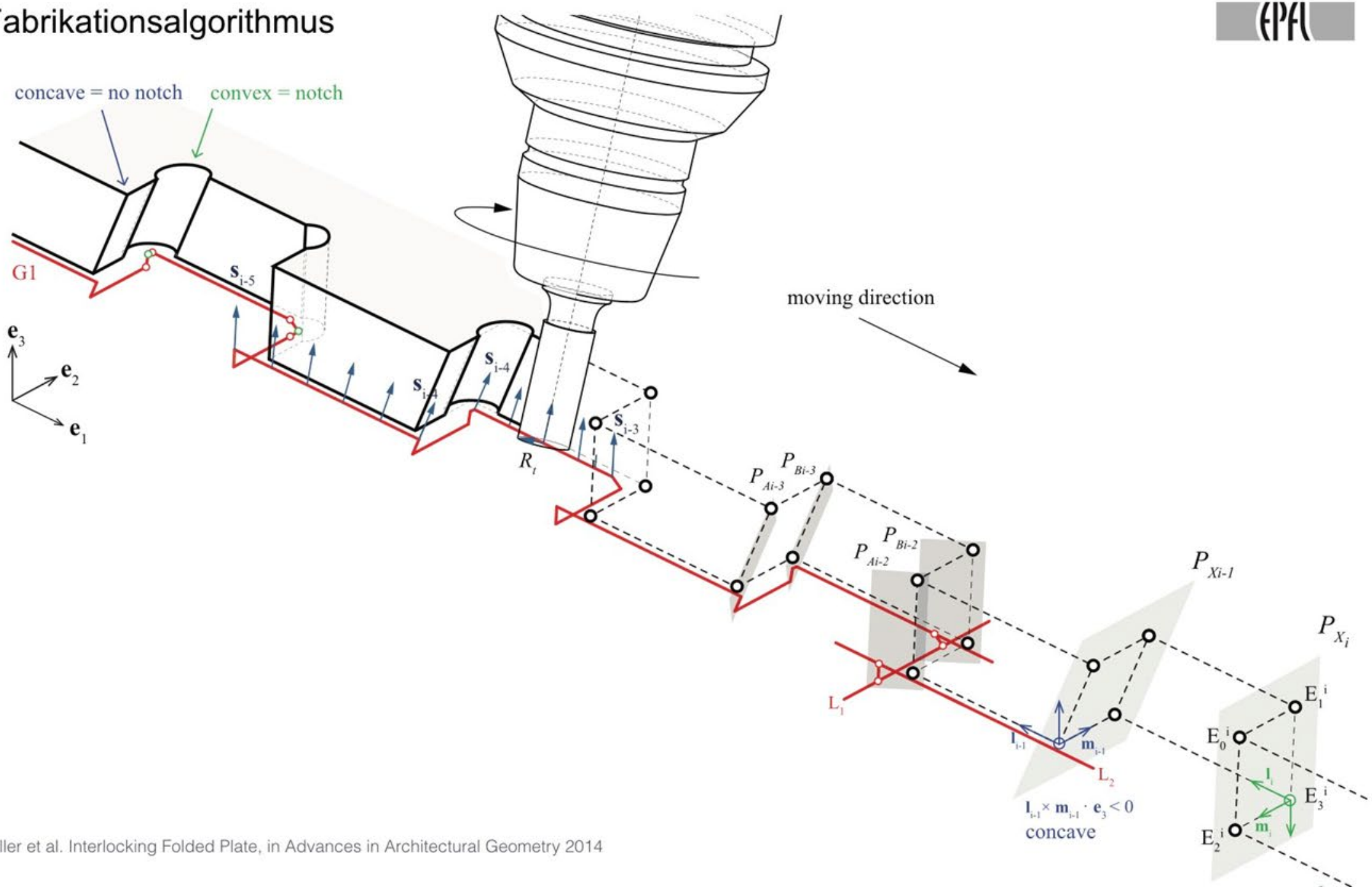
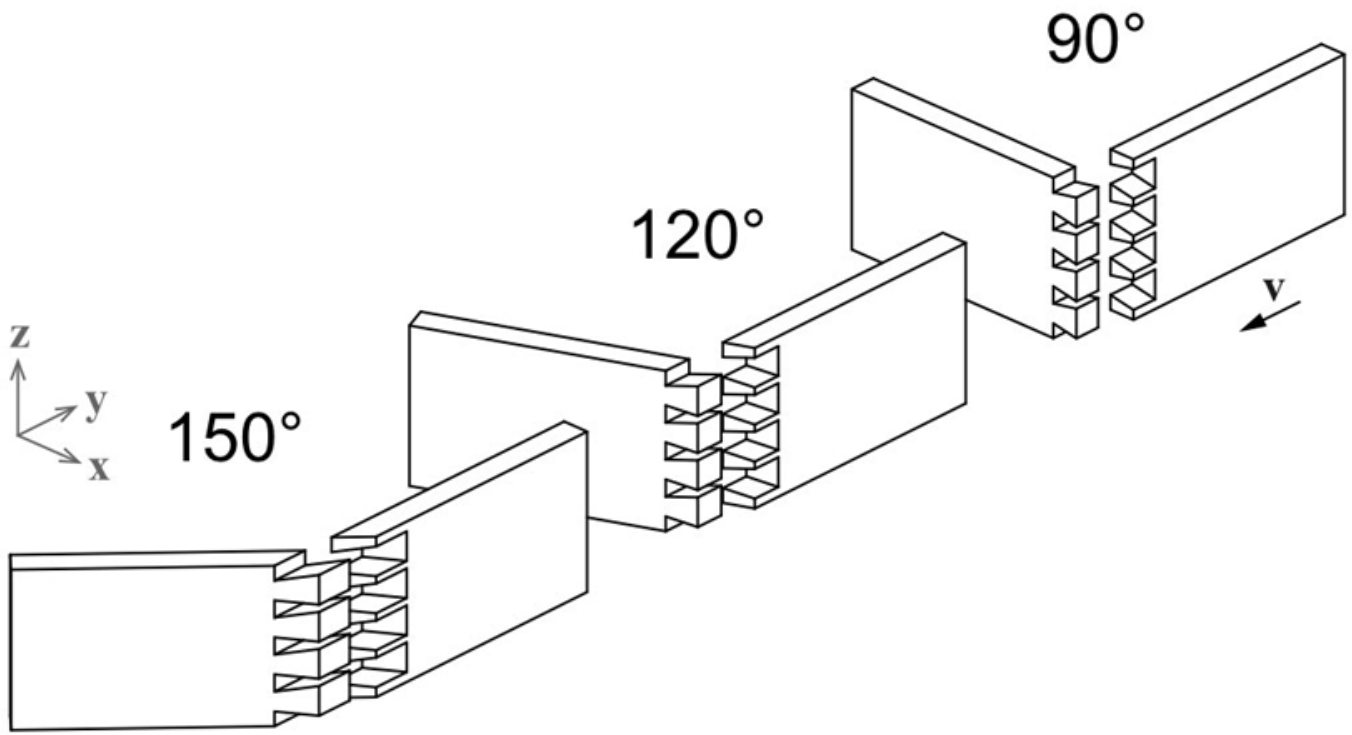


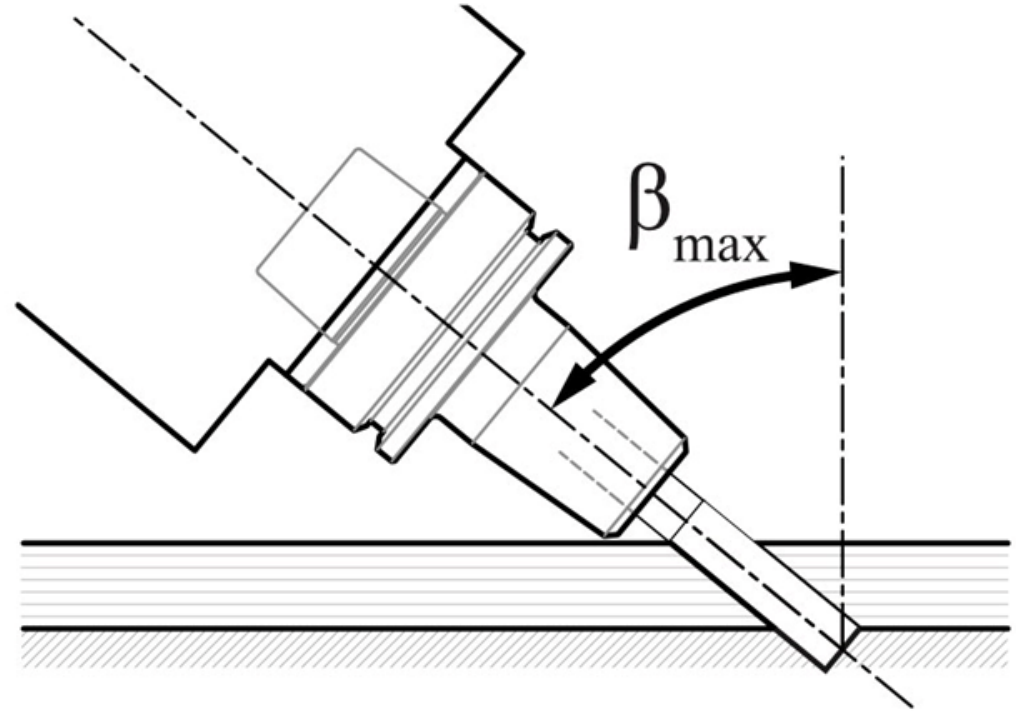
Fabrikationsalgorithmus



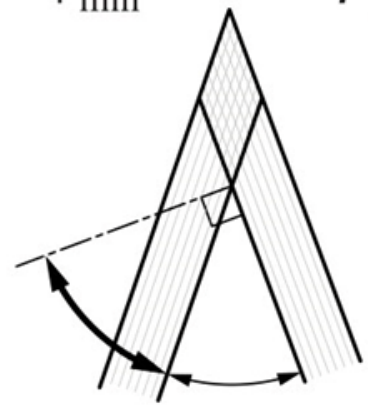
Robeller et al. Interlocking Folded Plate, in Advances in Architectural Geometry 2014

Variable Faltwinkel

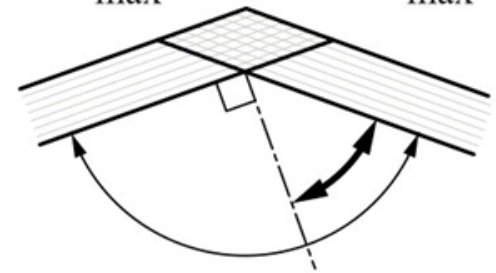




$\varphi_{min} = 90° - \beta_{max}$

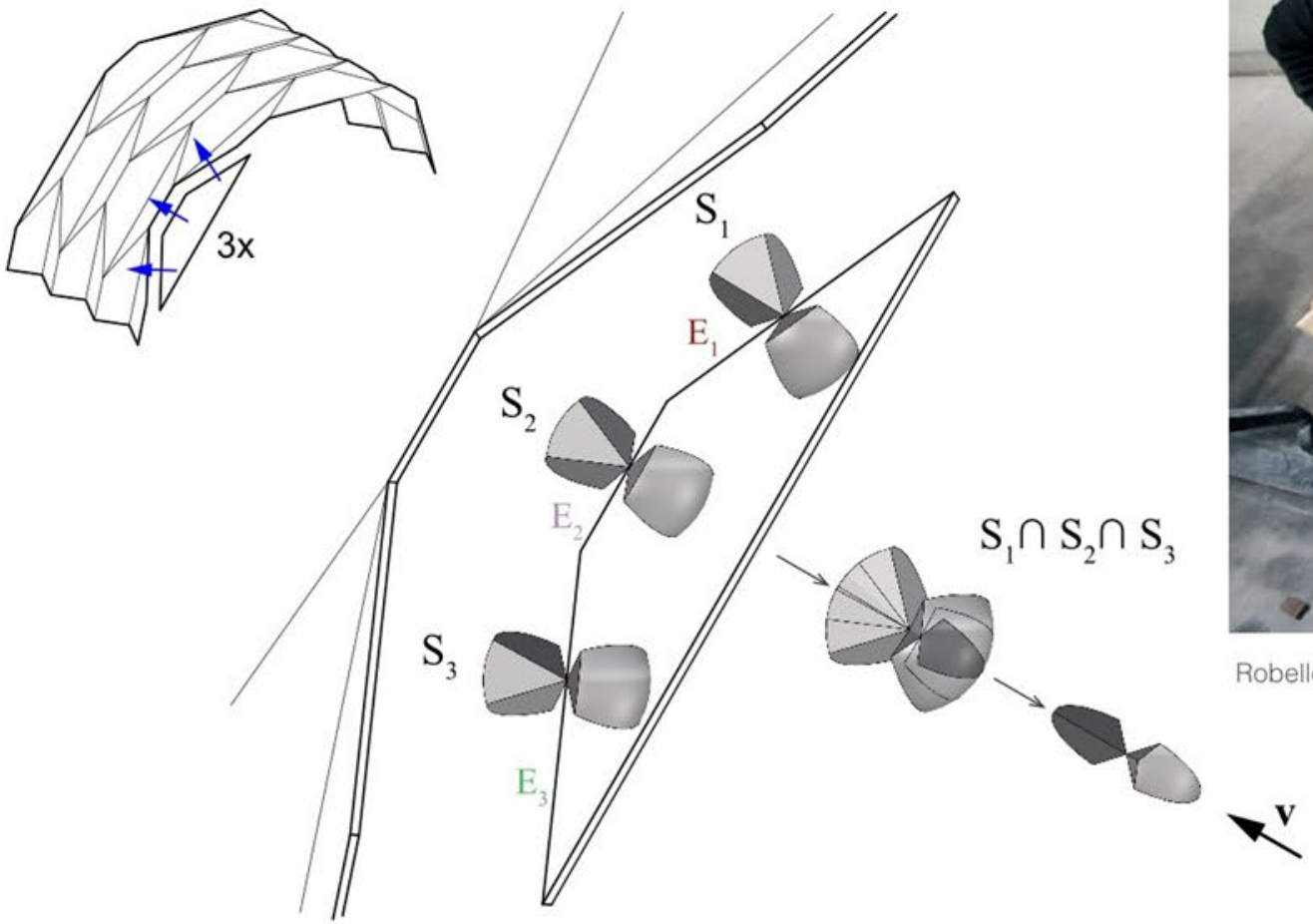


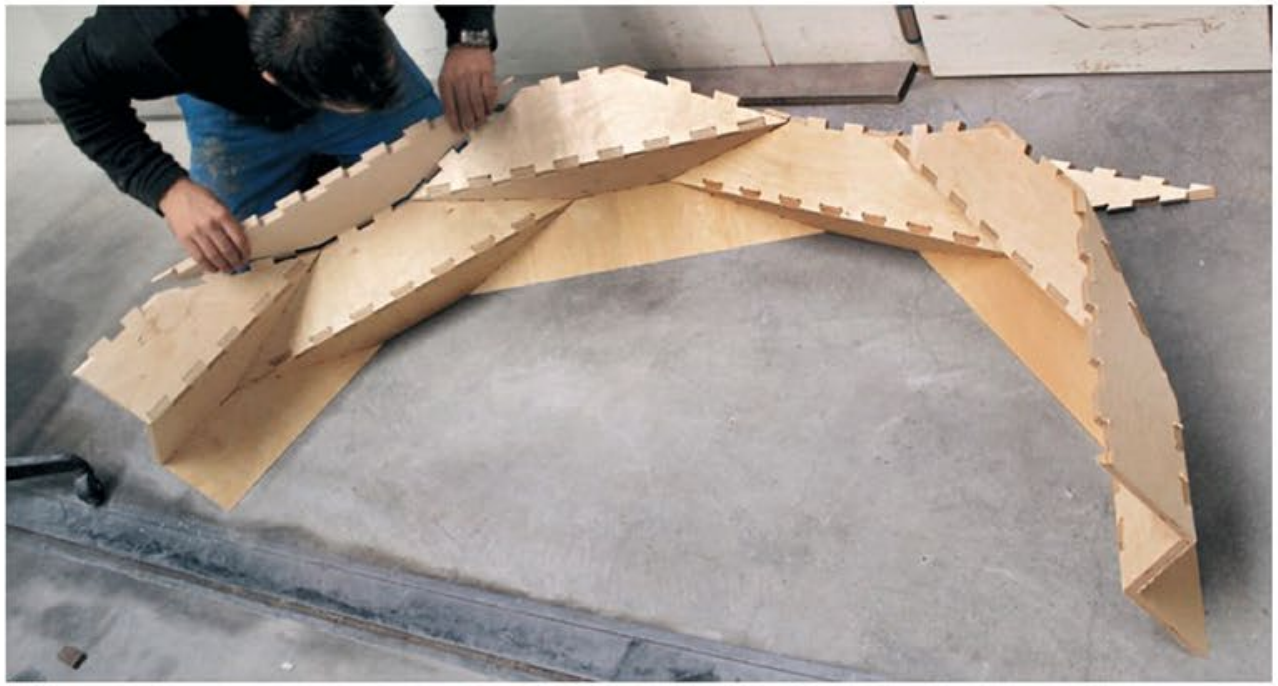
$\varphi_{max} = 90° + \beta_{max}$



Robeller et al. Interlocking Folded Plate, in Advances in Architectural Geometry 2014

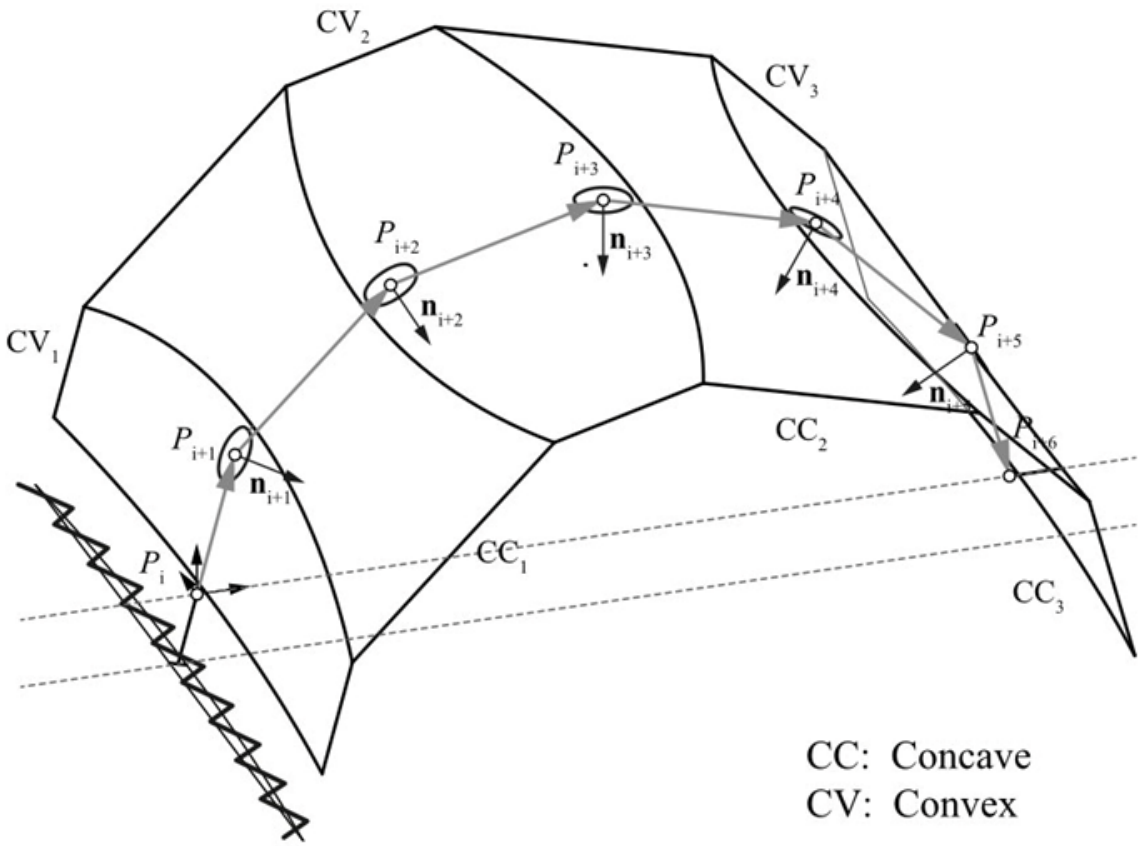
Gleichzeitiger Einschub mehrerer nicht-paralleler Kanten, 2014

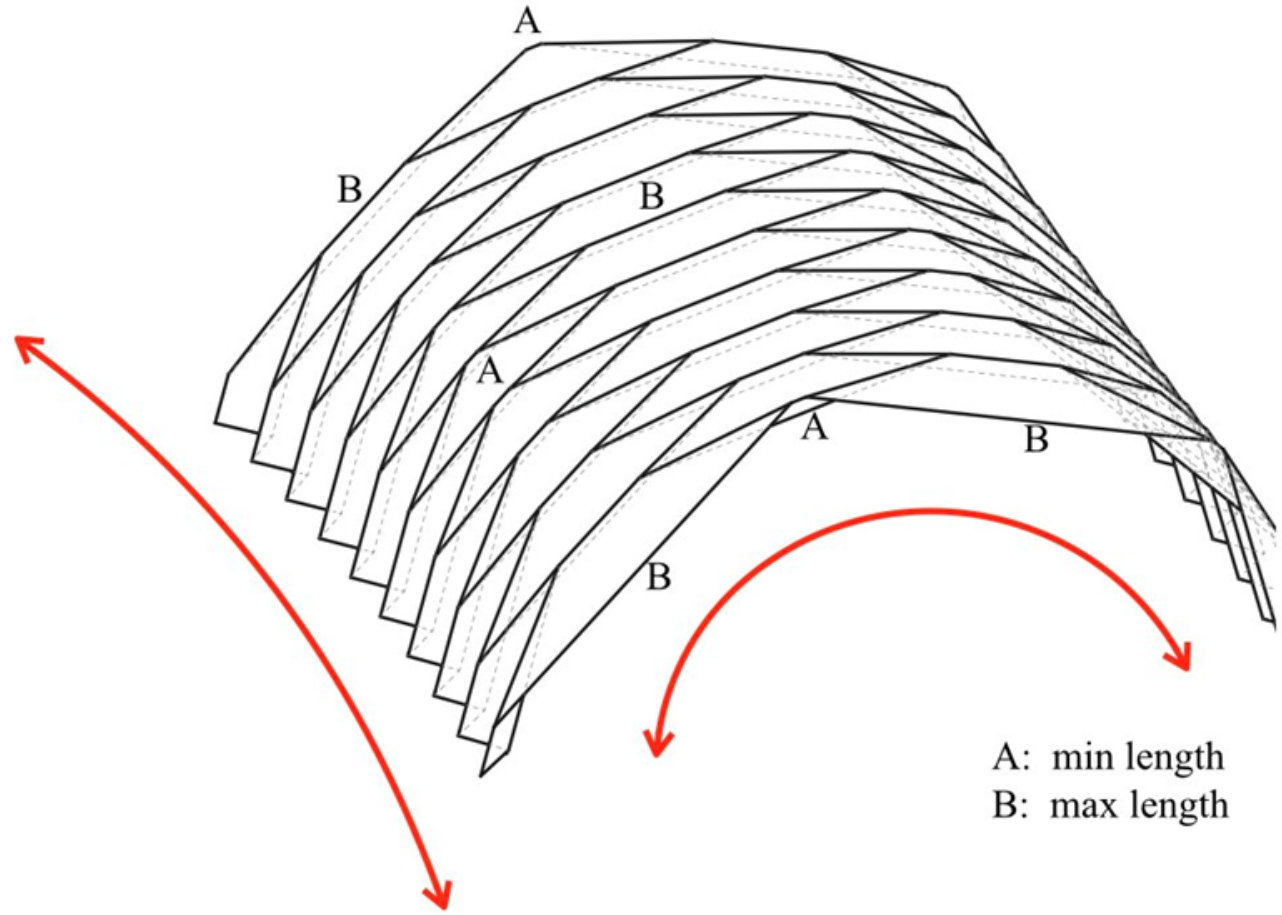




Robeller et al. Interlocking Folded Plate, in Advances in Architectural Geometry 2014

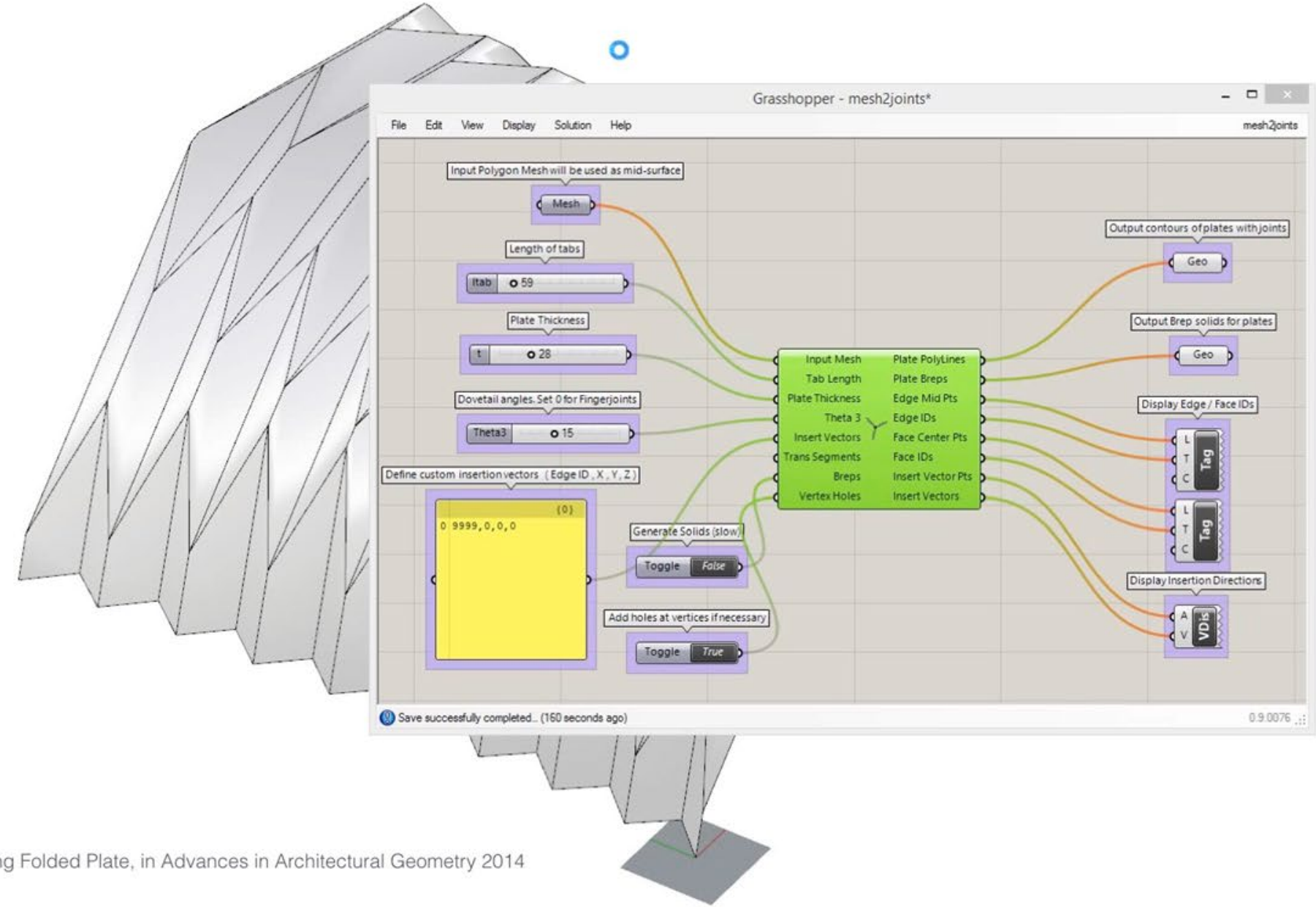
Zweifach gekrümmte Faltwerksschale





Robeller et al. Interlocking Folded Plate, in Advances in Architectural Geometry 2014

Zweifach gekrümmte Faltwerksschale



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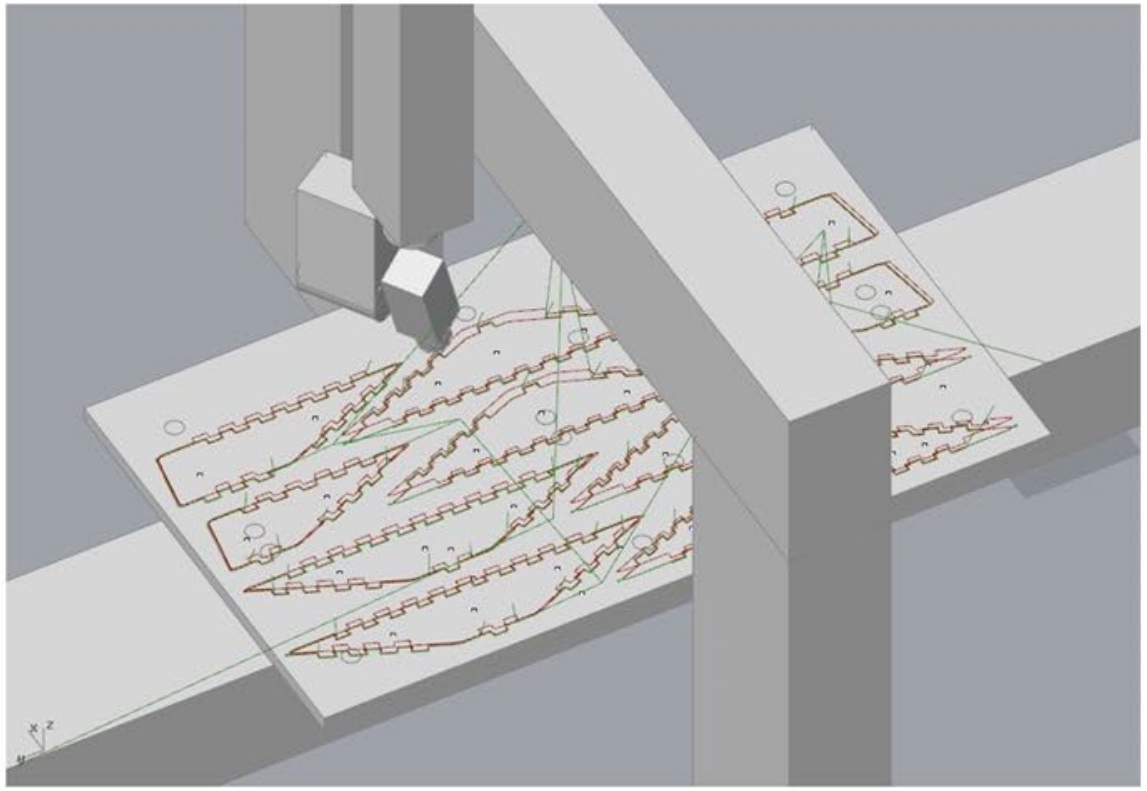
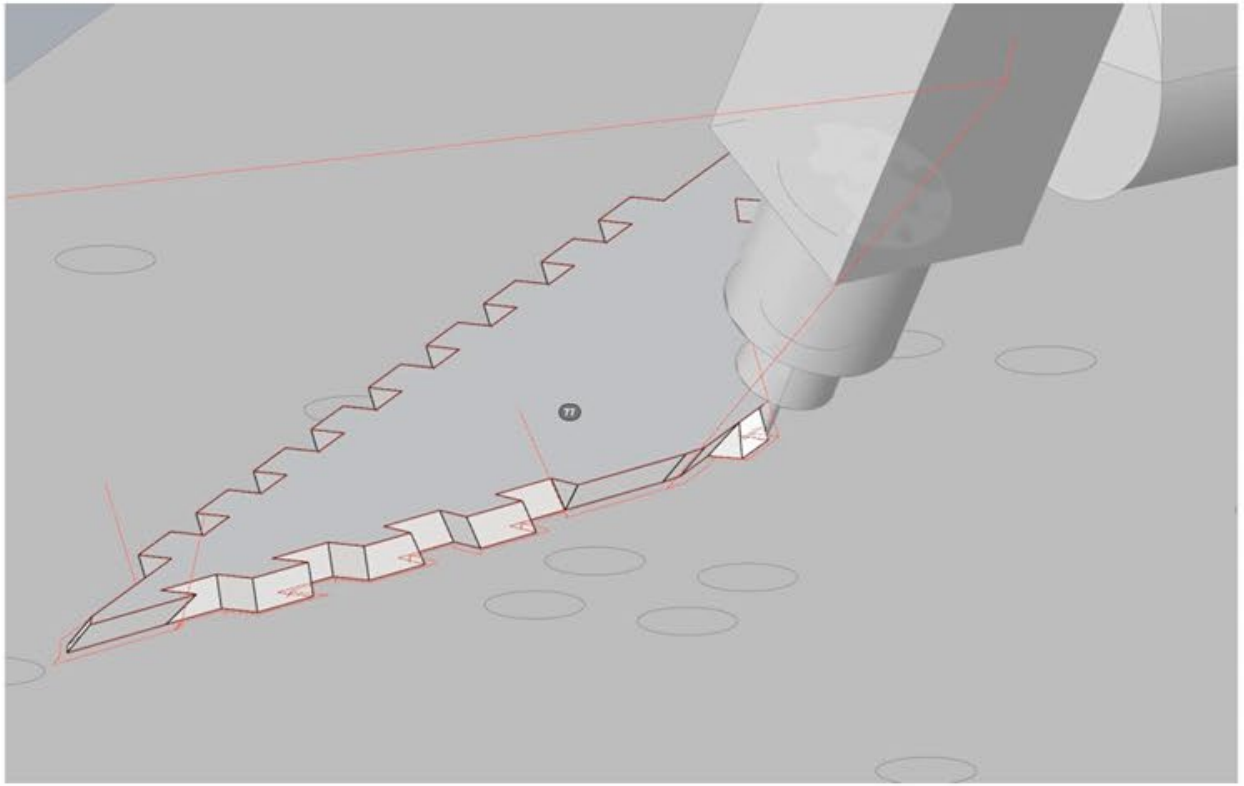
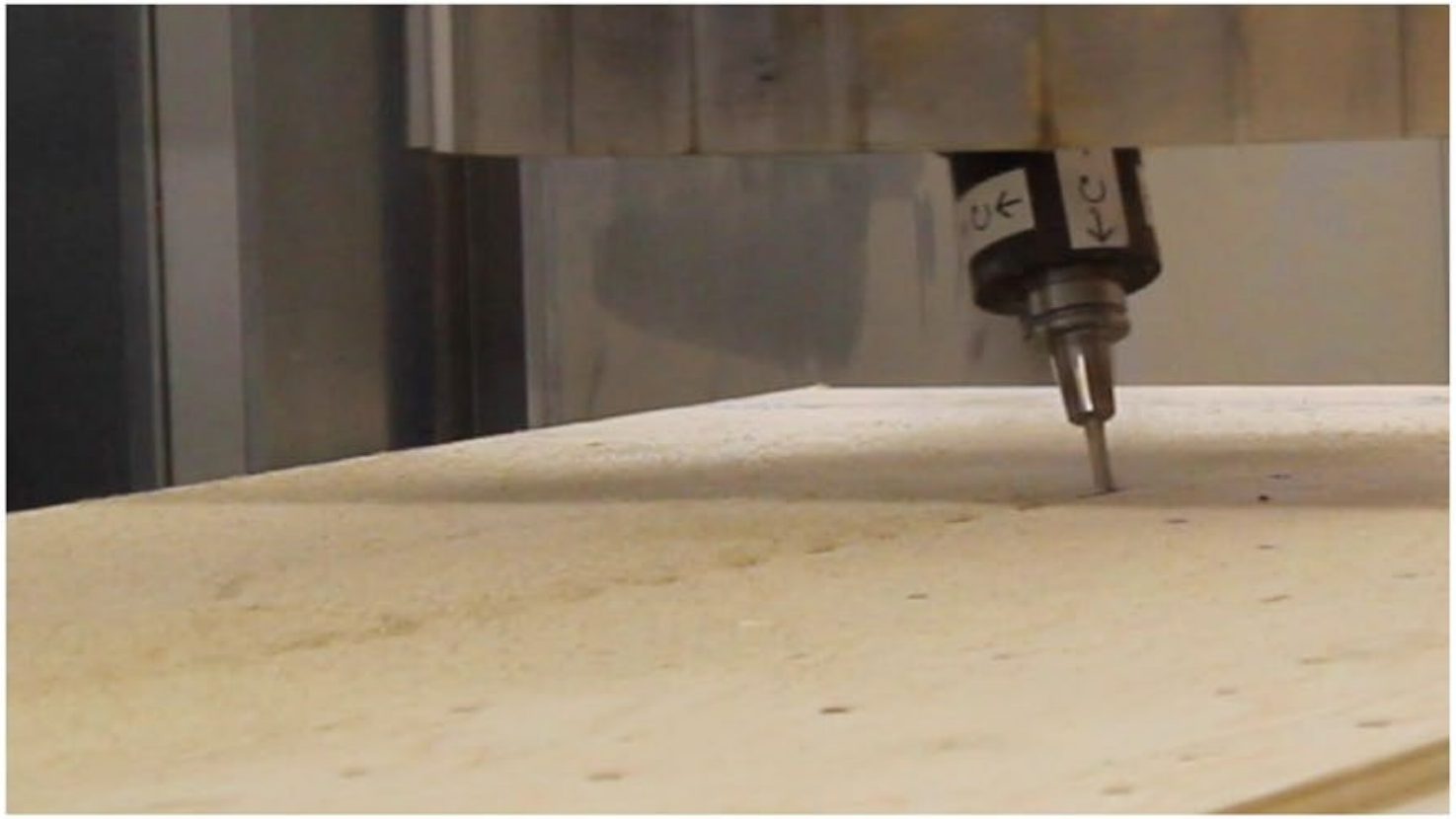
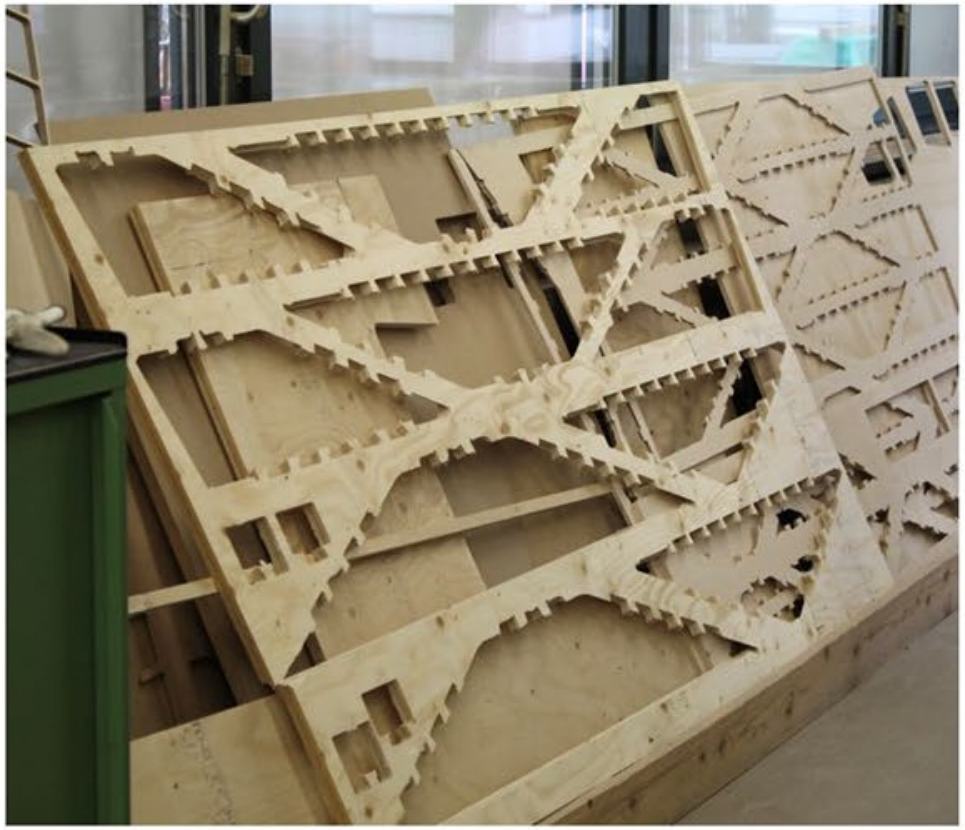
Fabrikation

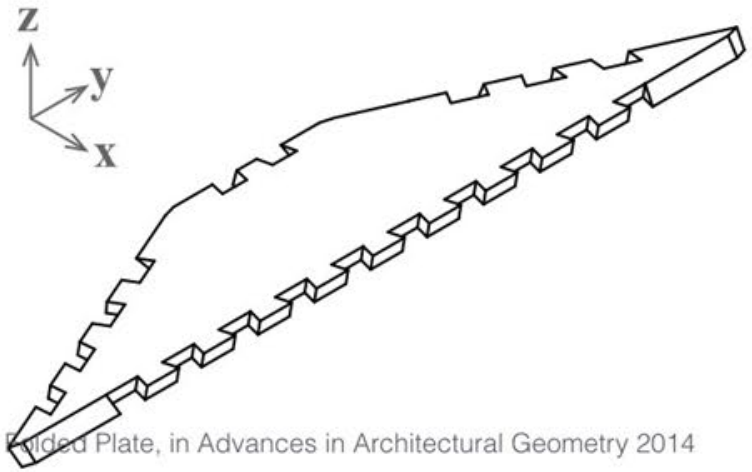




Robeller et al. Interlocking Folded Plate, in Advances in Architectural Geometry 2014

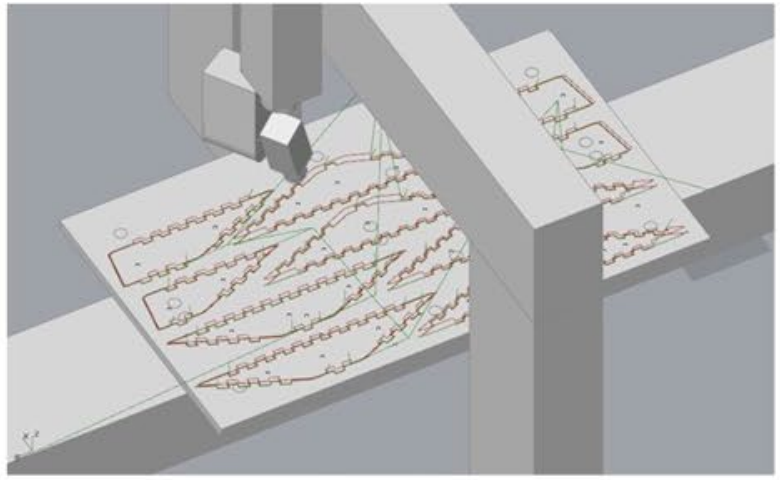






Robeller et al. Interlocking Folded Plate, in Advances in Architectural Geometry 2014

Integral befestigtes Tragwerk aus Holzplatten, 2014



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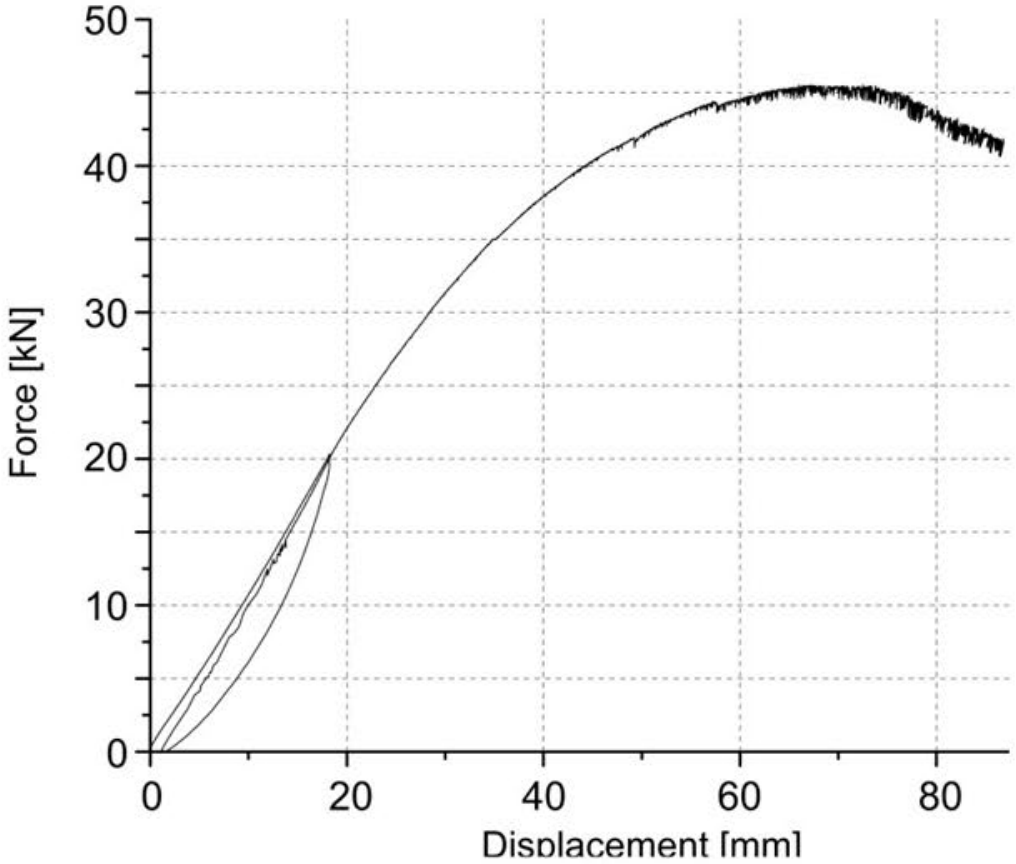
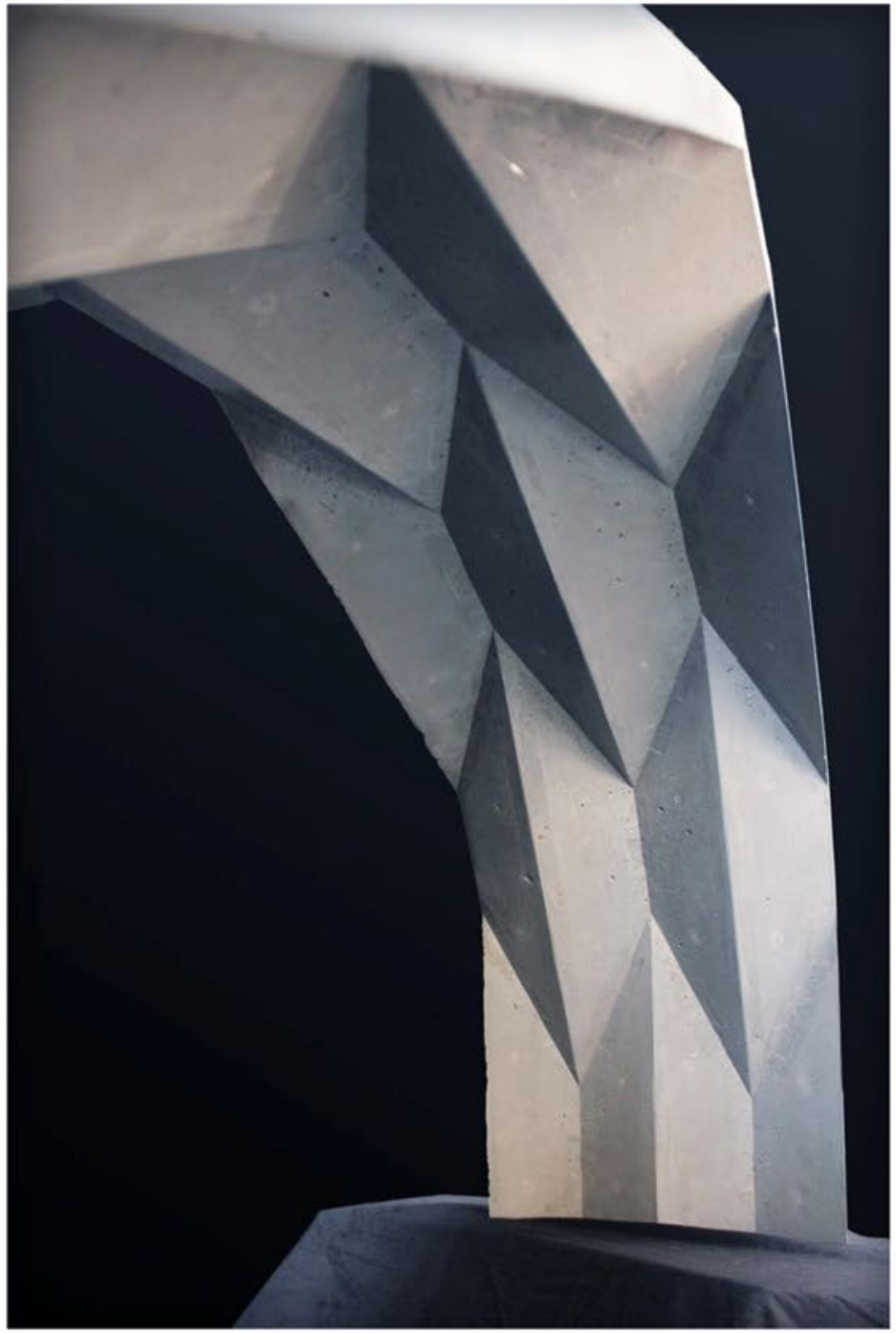
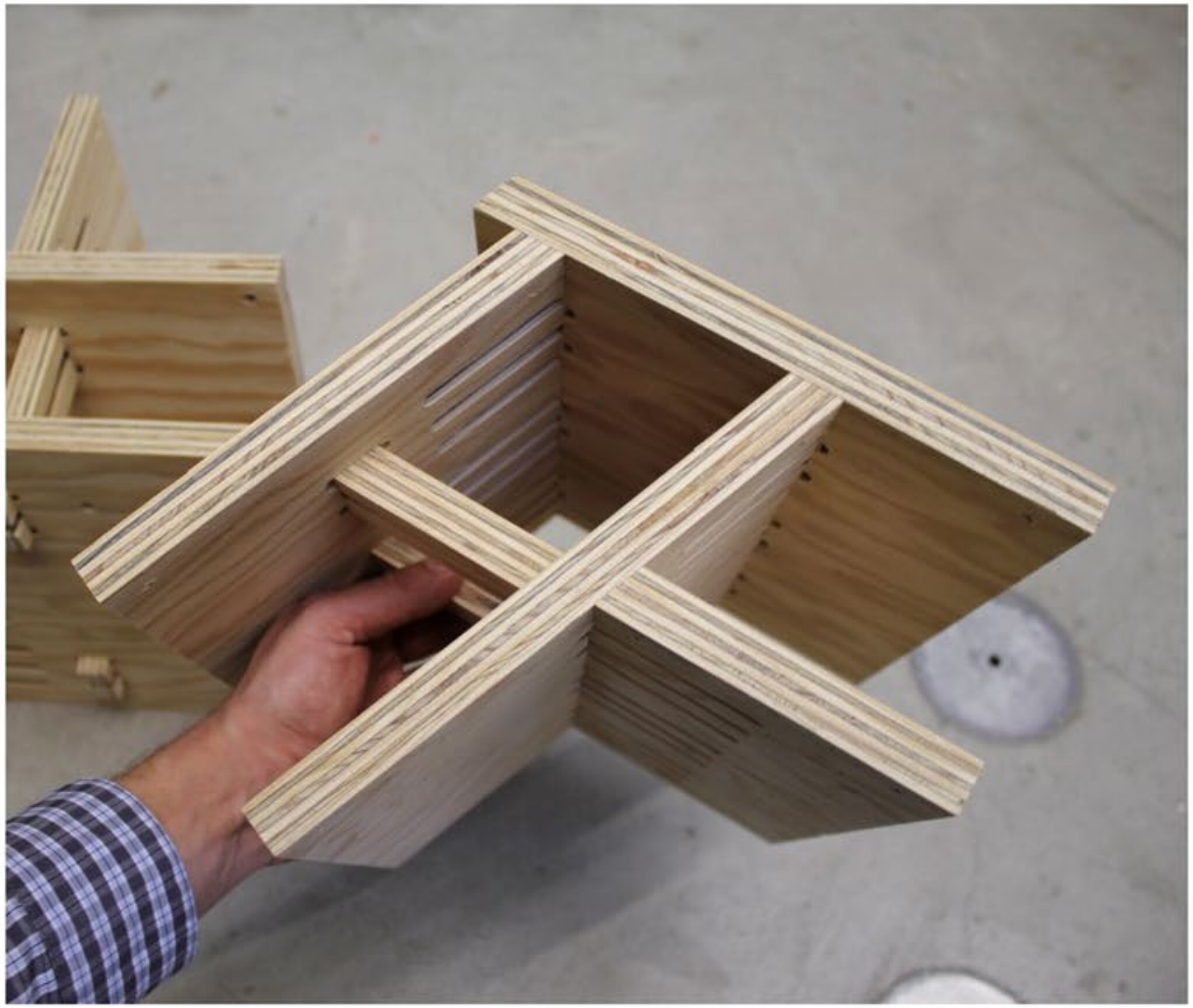
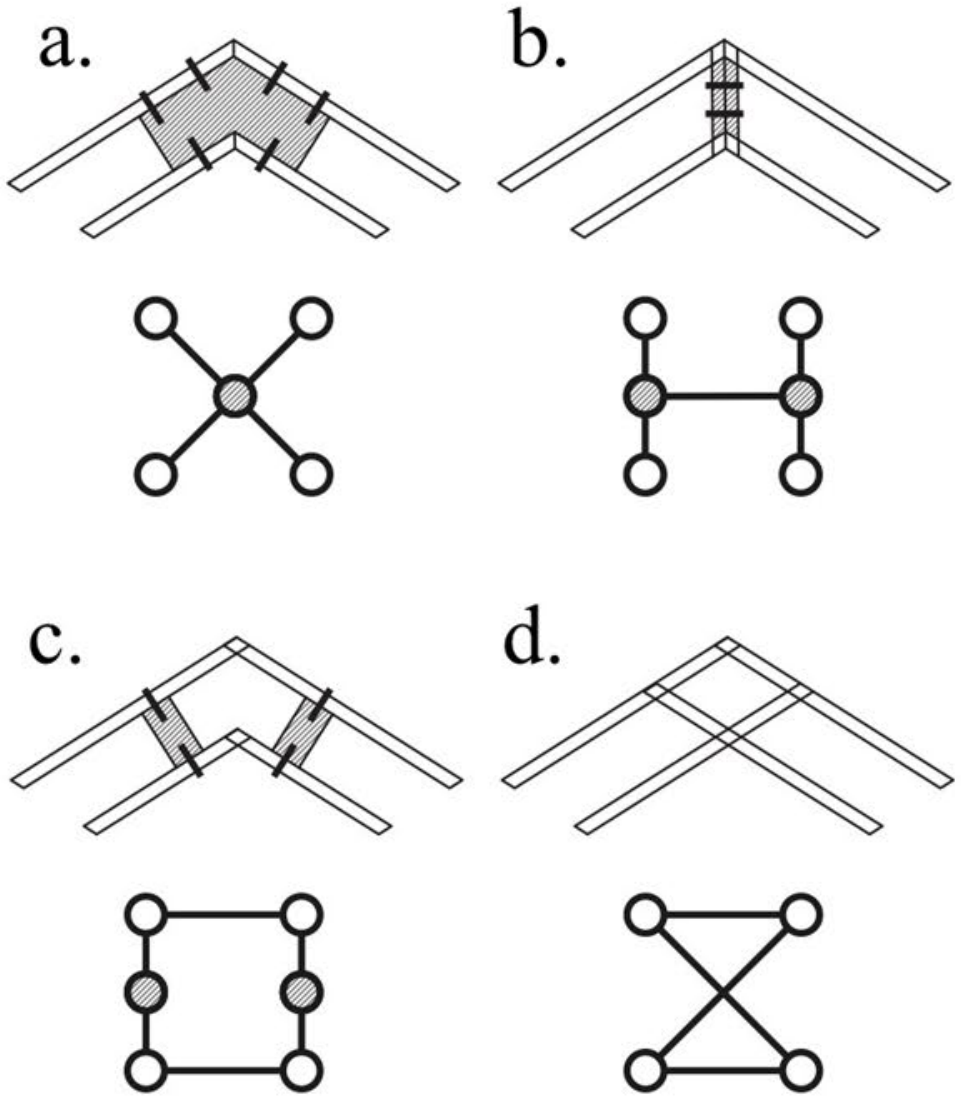


Robeller and Weinand, Interlocking Folded Plate, in International Journal of Space Structures, 2015

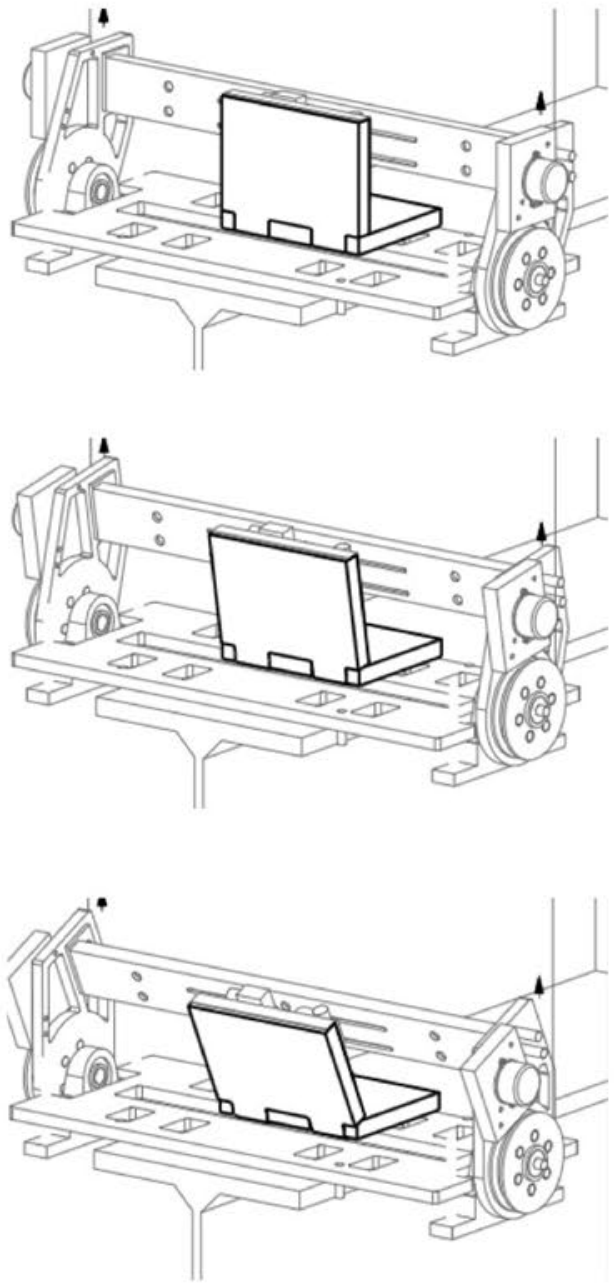


Zweischichtige Faltverbindung, 2014

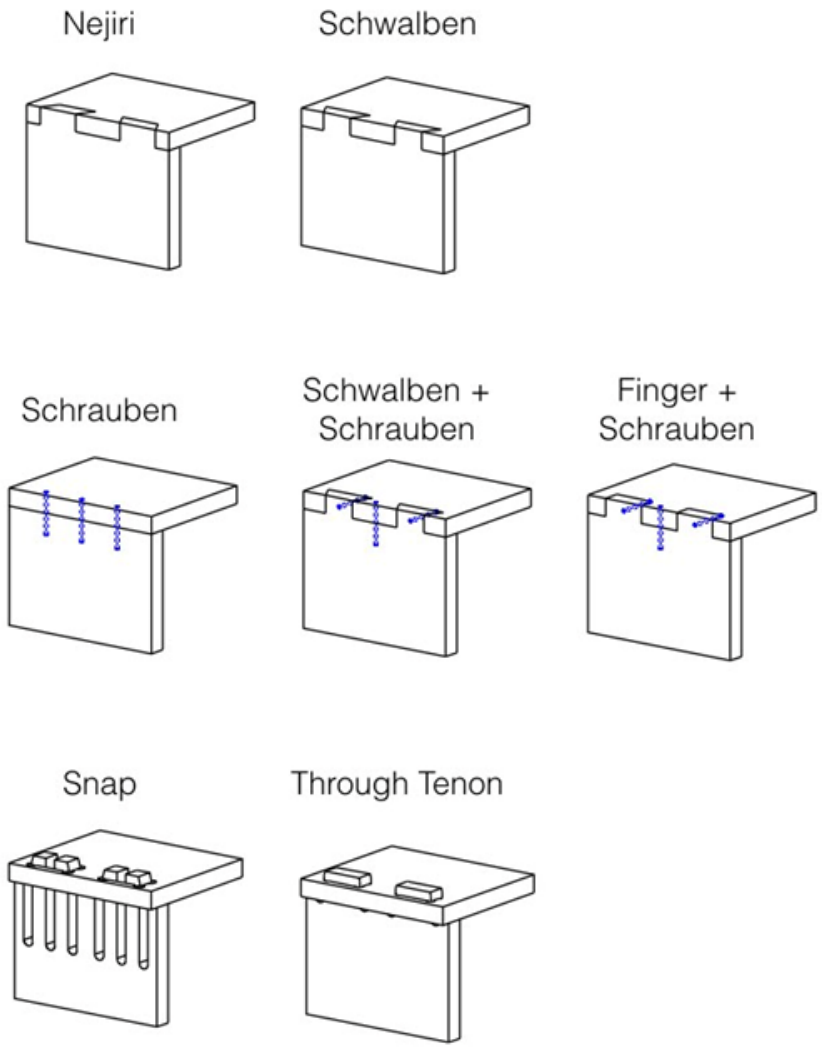


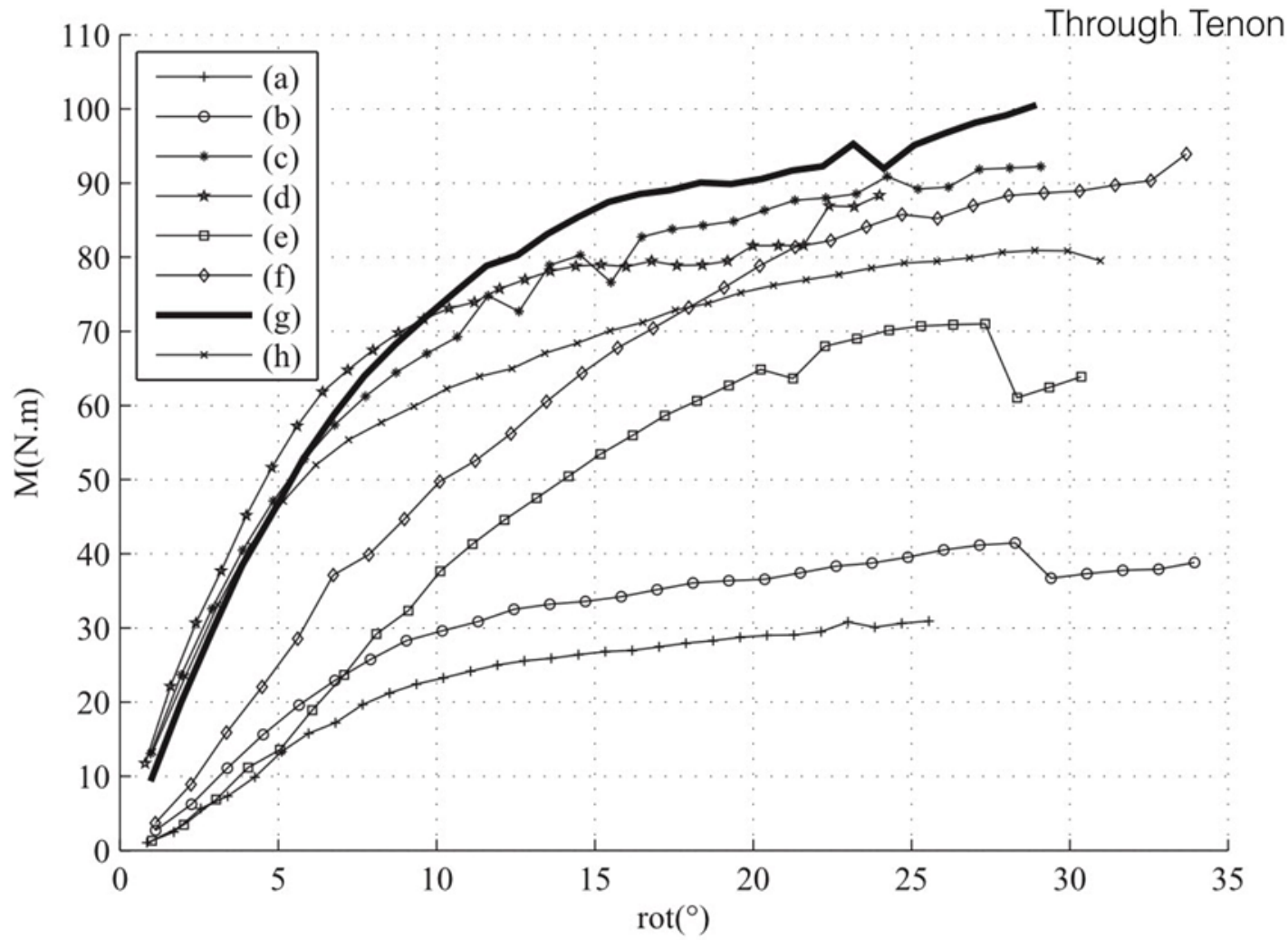


Robeller C. Integral Attachment for Timber Folded Plate Structure, PhD Thesis

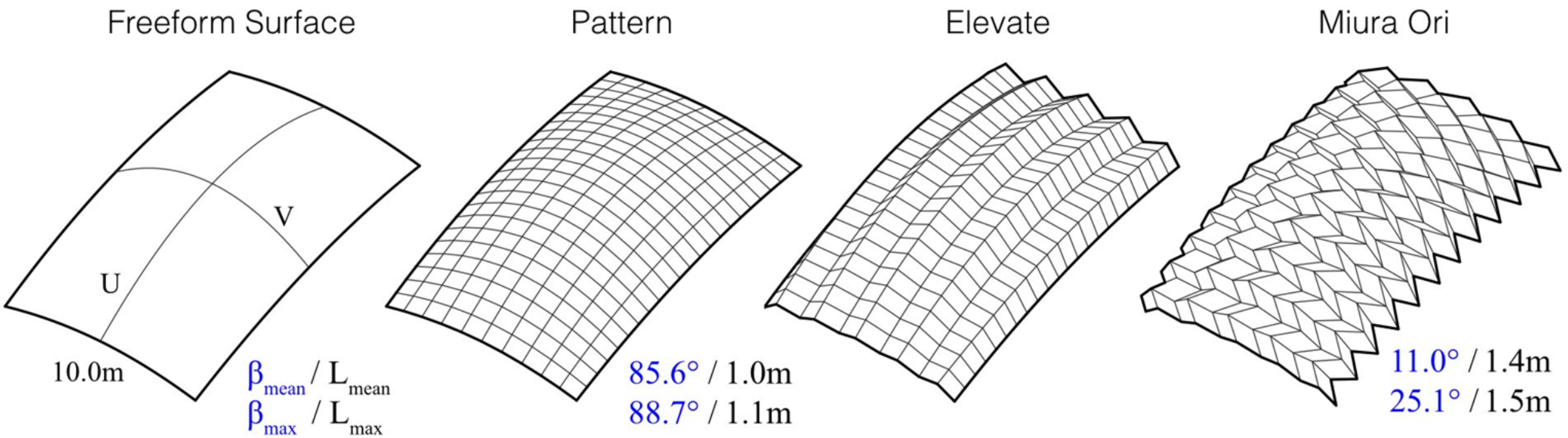


Roche, S. Rotational Stiffness of Joints at Ridges in Folded Plate Structures, 2014

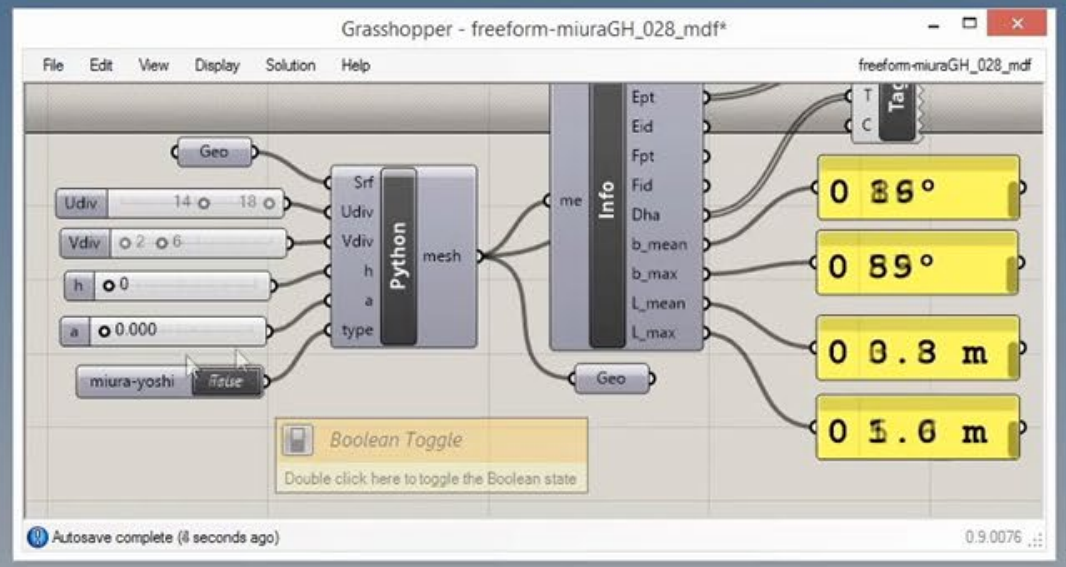


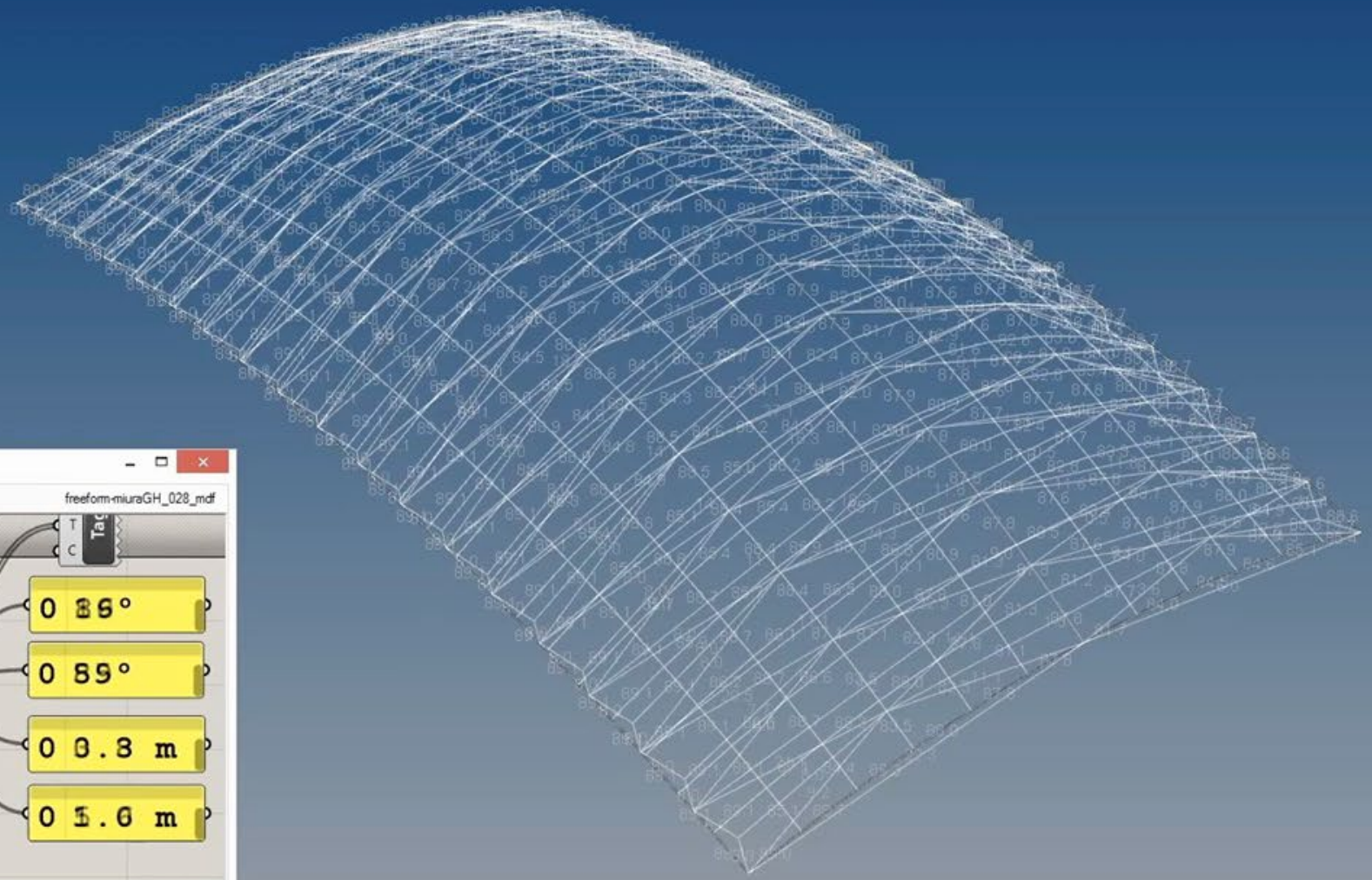


Roche, S. Rotational Stiffness of Joints at Ridges in Folded Plate Structures, 2014



Robeller and Weinand, *Fabrication Aware Design of Folded Plate Structures with Double-through tenon joints*, in Robotic Fabrication in Architecture 2016





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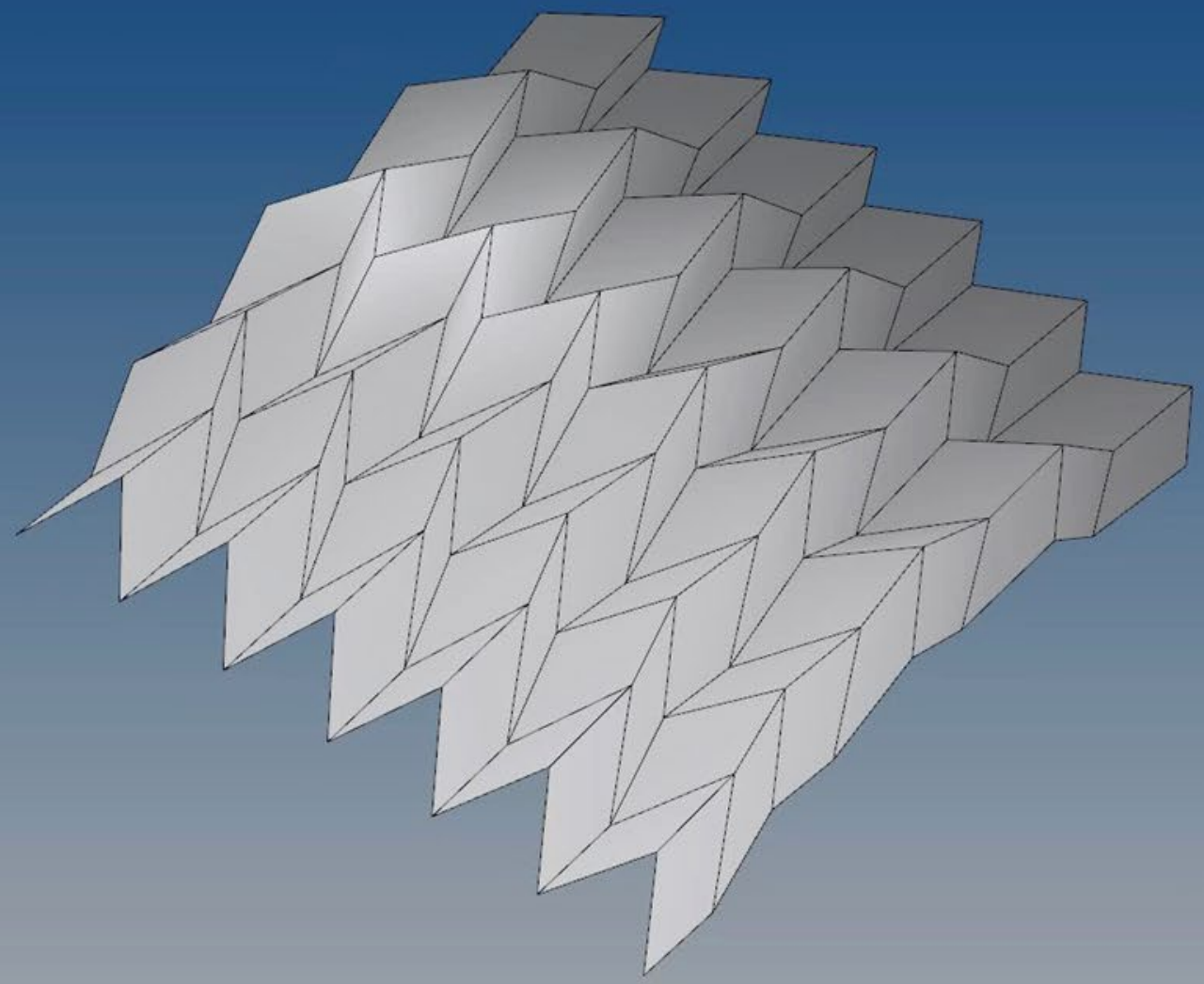
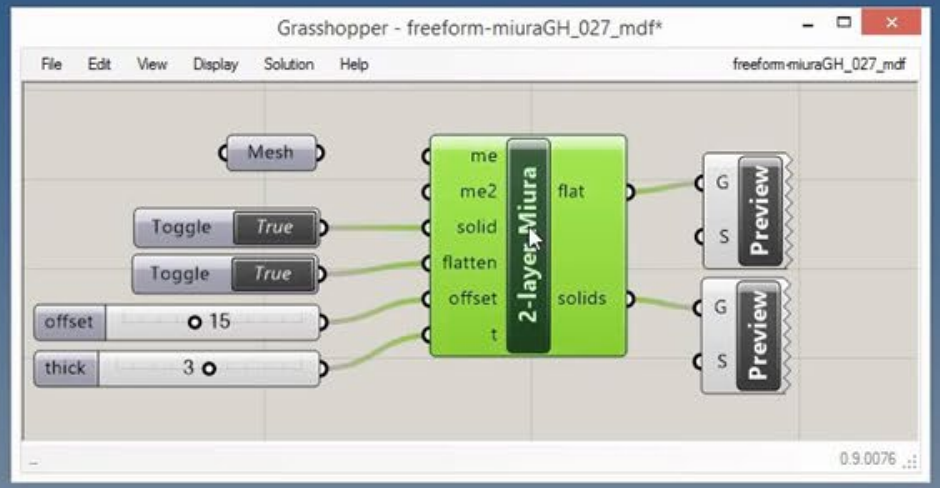
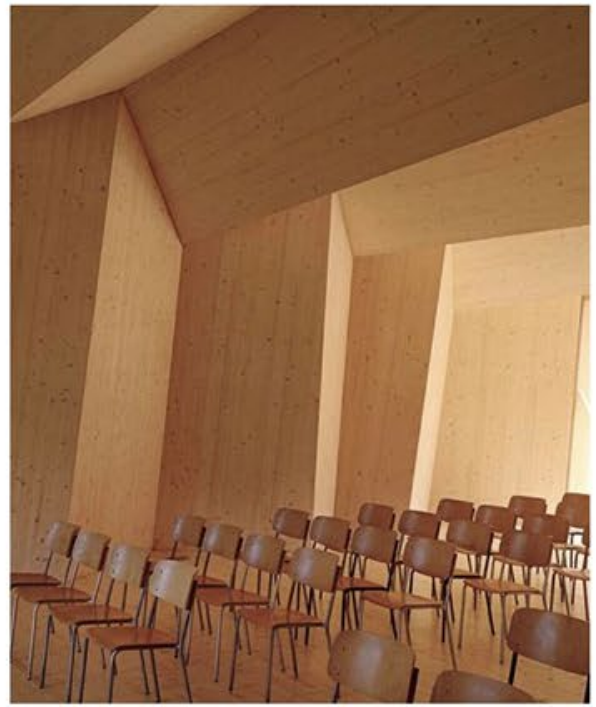
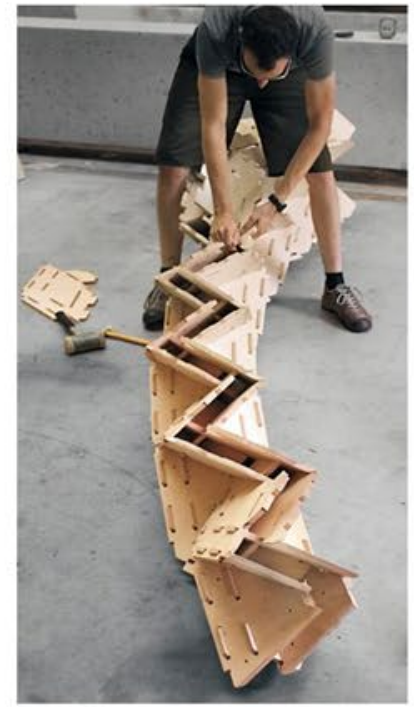




Robeller and Weinand, *Fabrication Aware Design of Folded Plate Structures with Double-through tenon joints*, in Robotic Fabrication in Architecture 2016

Robeller and Weinand, *Fabrication Aware Design of Folded Plate Structures with Double-through tenon joints*, in Robotic Fabrication in Architecture 2016

Weiterentwicklung von Faltwerken aus Holzplatten

2006 →	2008 →	2014 →	2015
			
Einfach gekrümmt	Rahmen	Zweifach gekrümmt	Zweifach gekrümmt
Gehrung	Gehrung	Schwalbenschwanzzinken	Zapfen-/Loch
Einschichtig	Einschichtig	Einschichtig	Zweischichtig
Abwickelbar	Abwickelbar	Abwickelbar	Abwickelbar
8	39	107	152

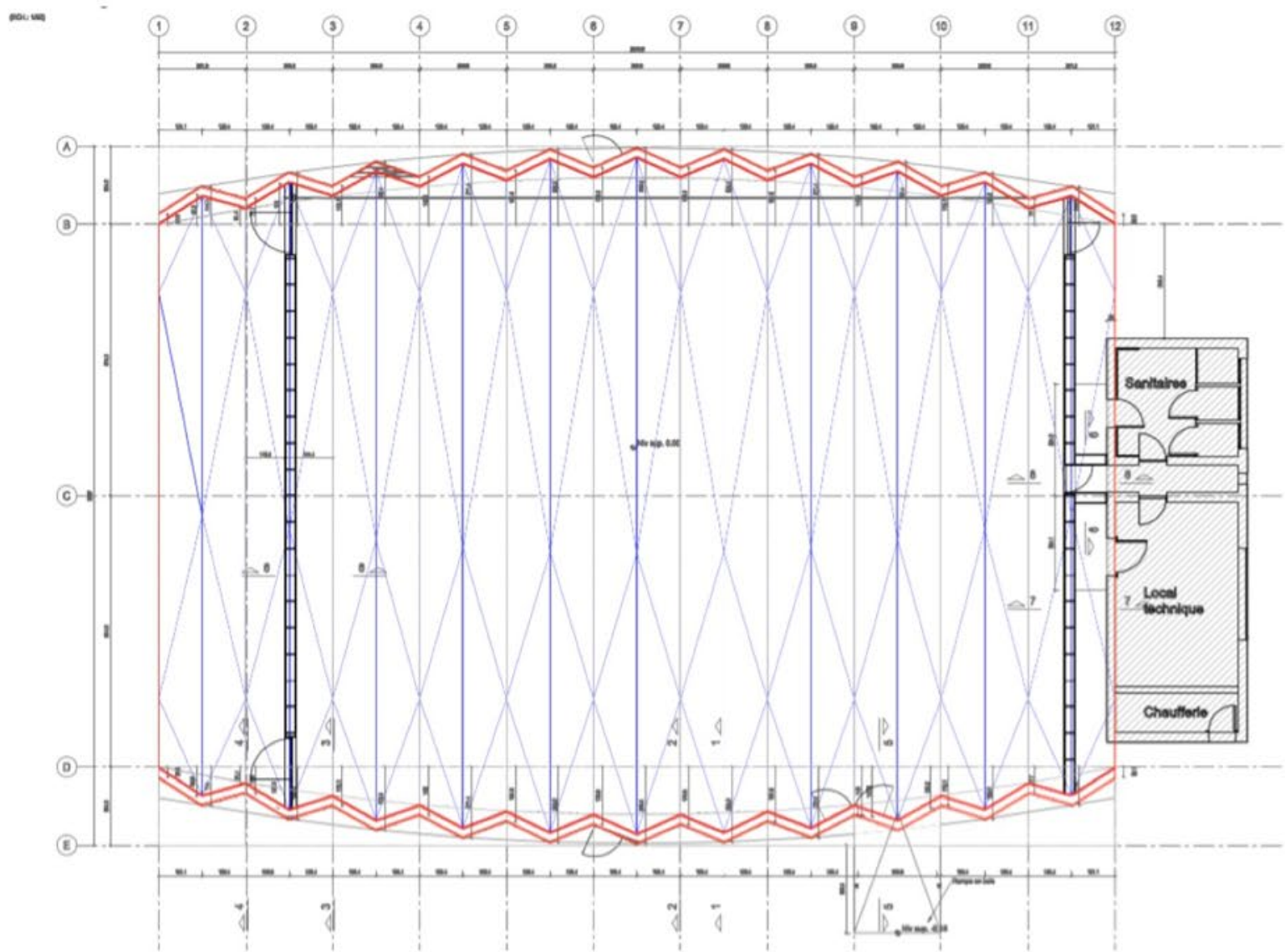
Théâtre Vidy Lausanne, 2016

Visualisierung

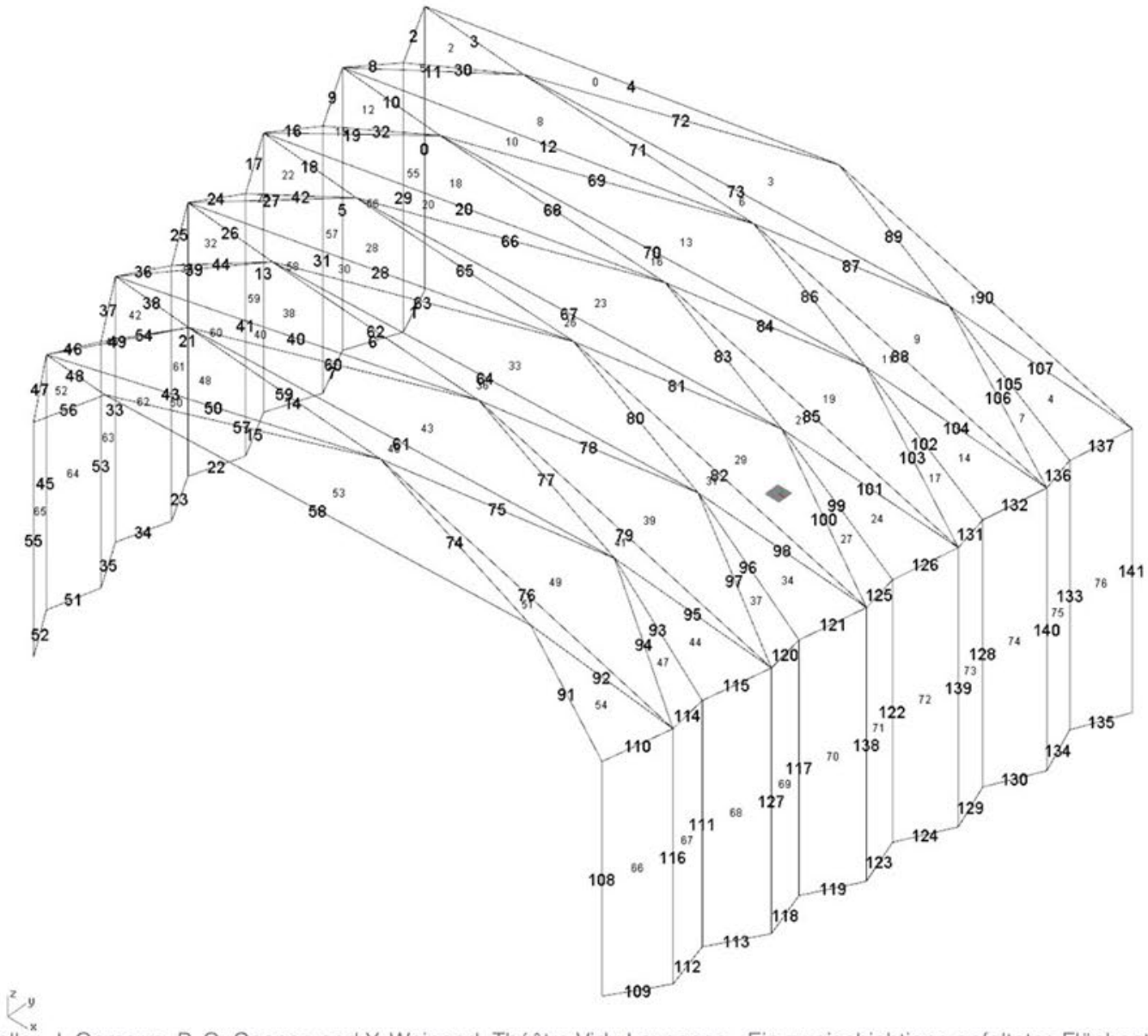
Wandsegment 1:1

Grundriss / Eckdaten

Grundfläche	538 m^2
Spannweite	16-20 m
Platten	304
Unterschiedl. P.	152
Verb. Gesamt	456
Verb. Baustelle	44 (22)



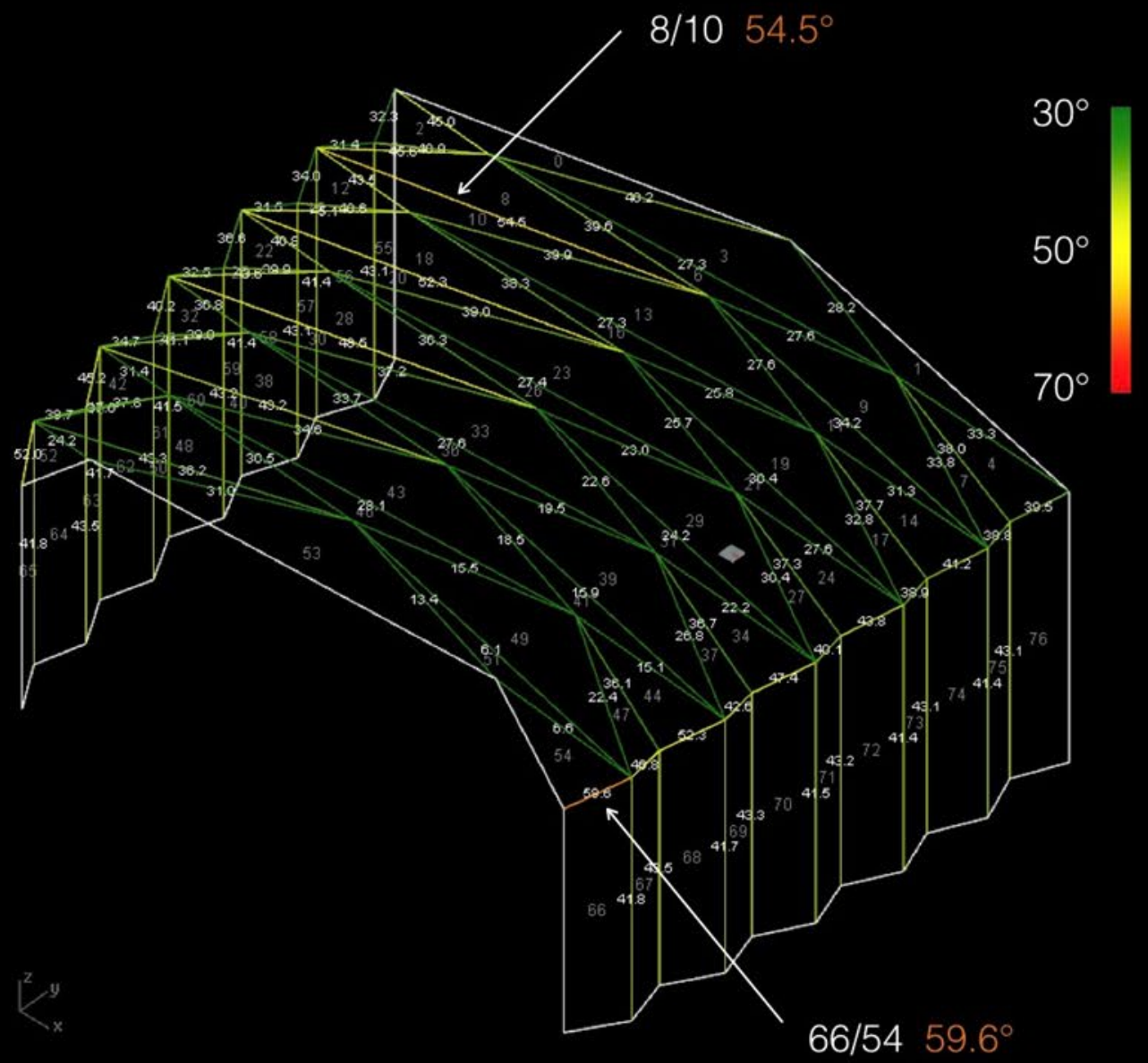
3D Polygonnetz Innenflächen

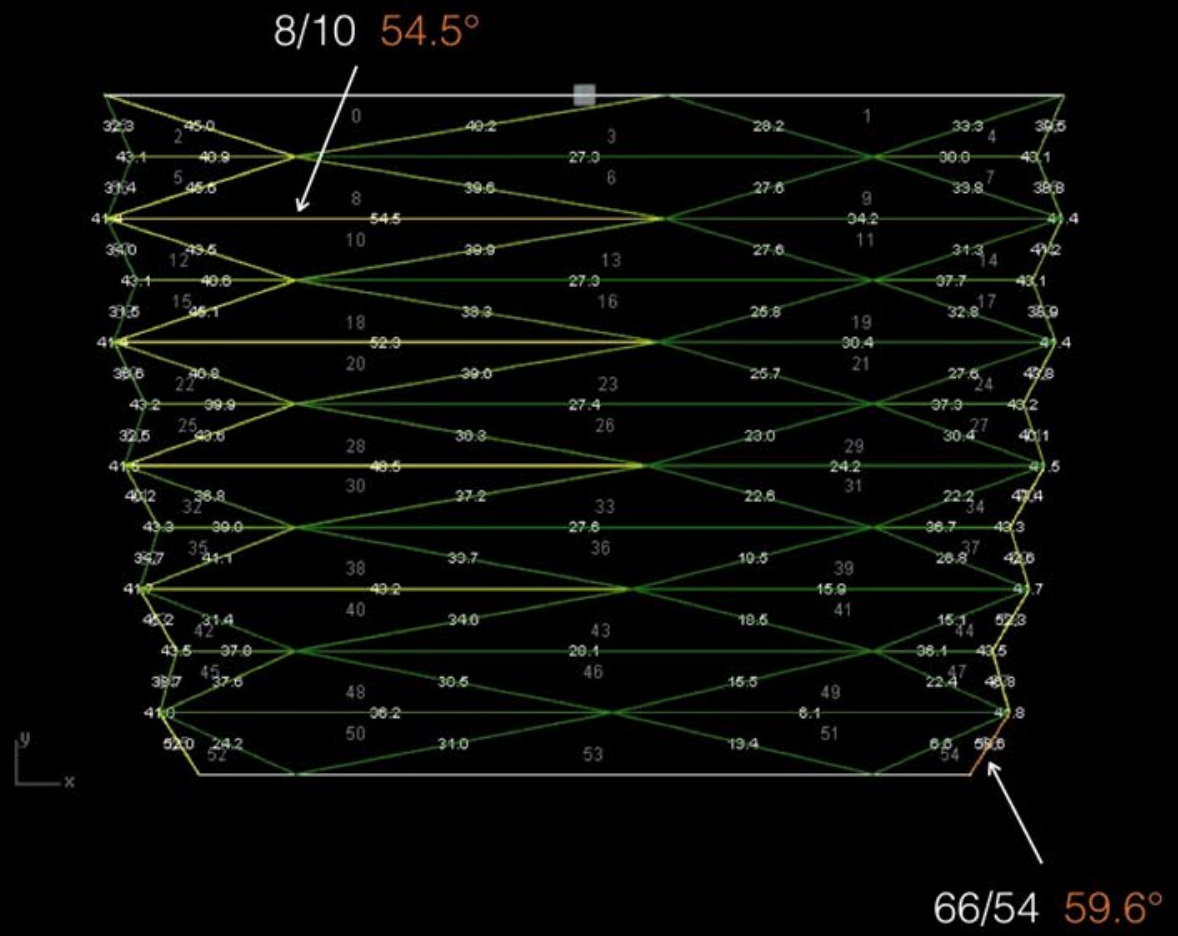


- Master Modell für die automatische Geometriegenerierung via CAD Plugin
- DCEL Datenstruktur: Doppelt verkettete Kantenlinien für Nachbarschaftsabfragen

C. Robeller, J. Gamerro, P.-O. Coanon and Y. Weinand. Théâtre Vidy Lausanne - Ein zweischichtiges gefaltetes Flächentragwerk aus Brettsperrholz. S-WIN FBK Weinfelden 2016

Polygonnetz Faltwinkel





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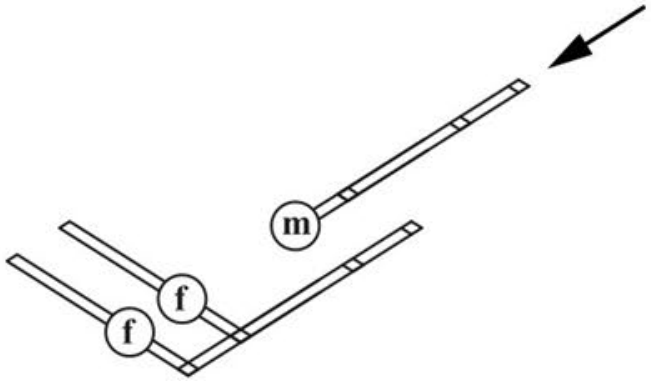
Regulärer / Umgekehrter Einschub



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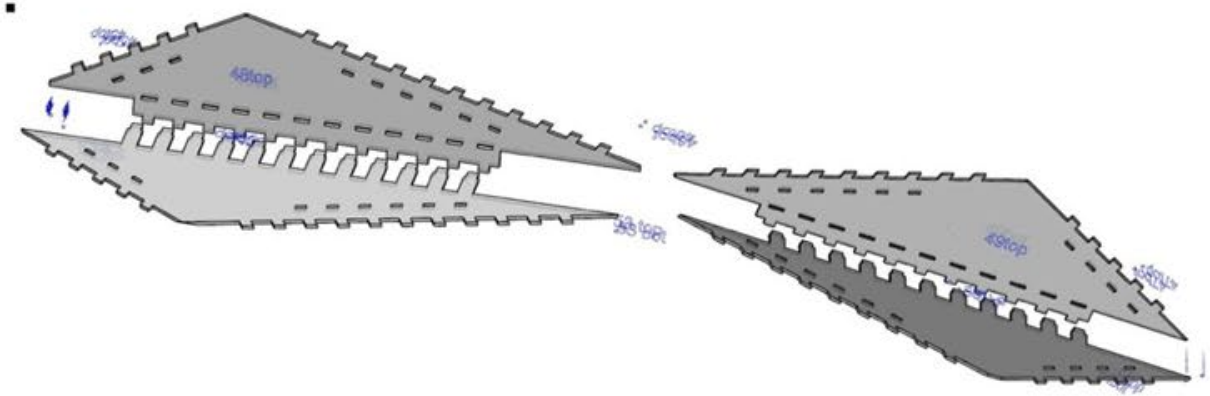

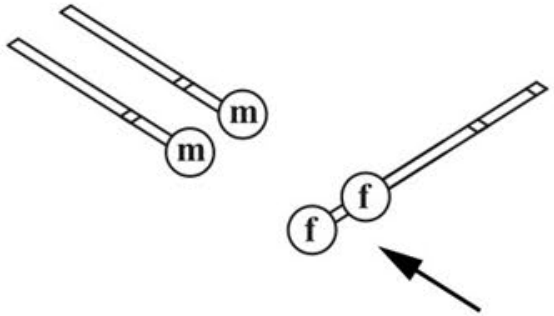

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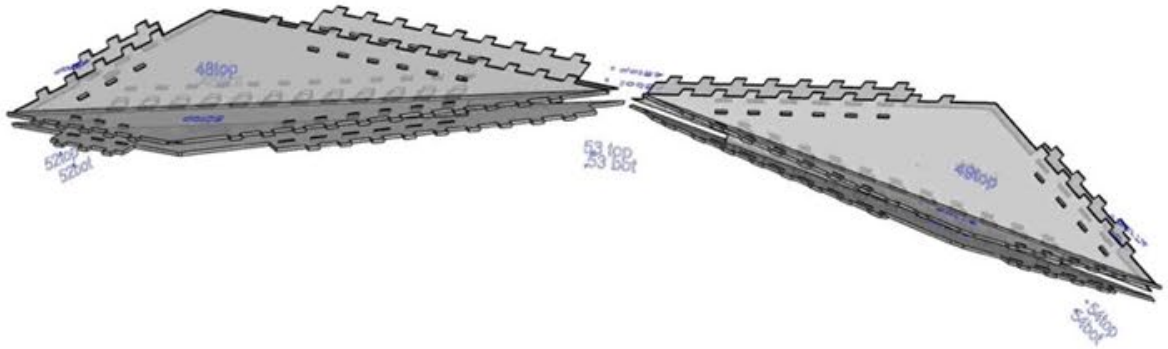

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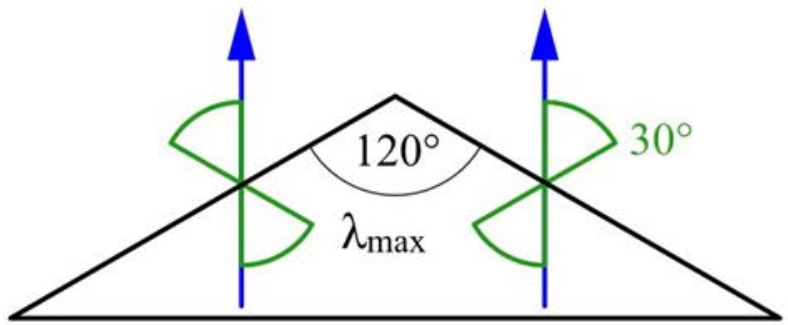
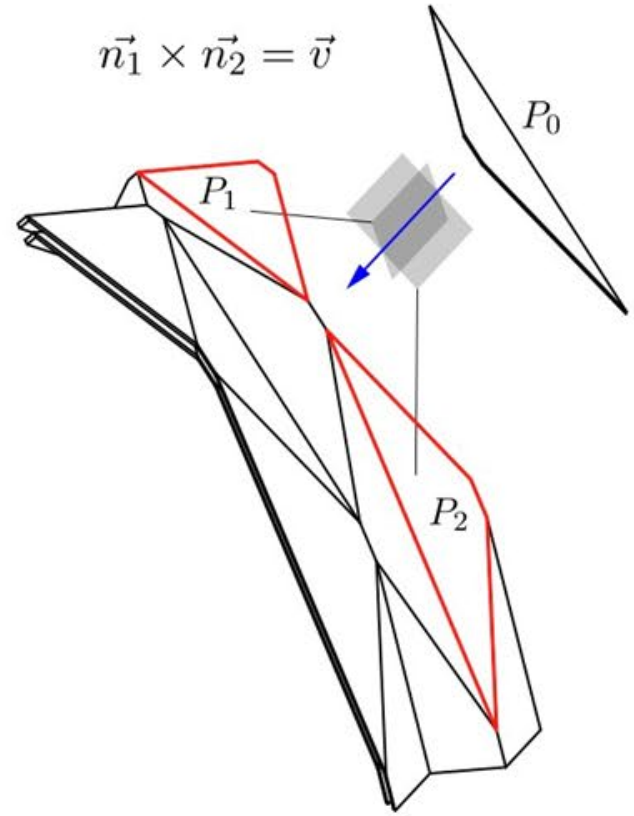
Gleichzeitiger Einschub mehrerer Kanten





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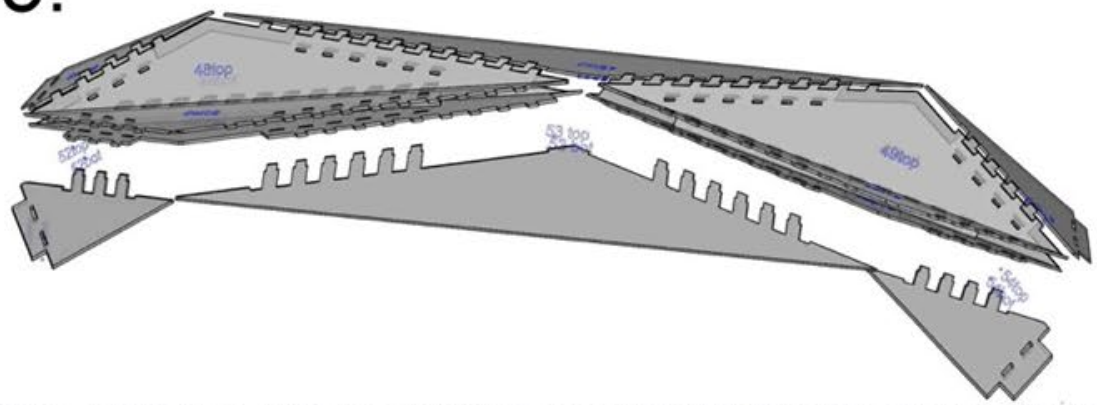

4.

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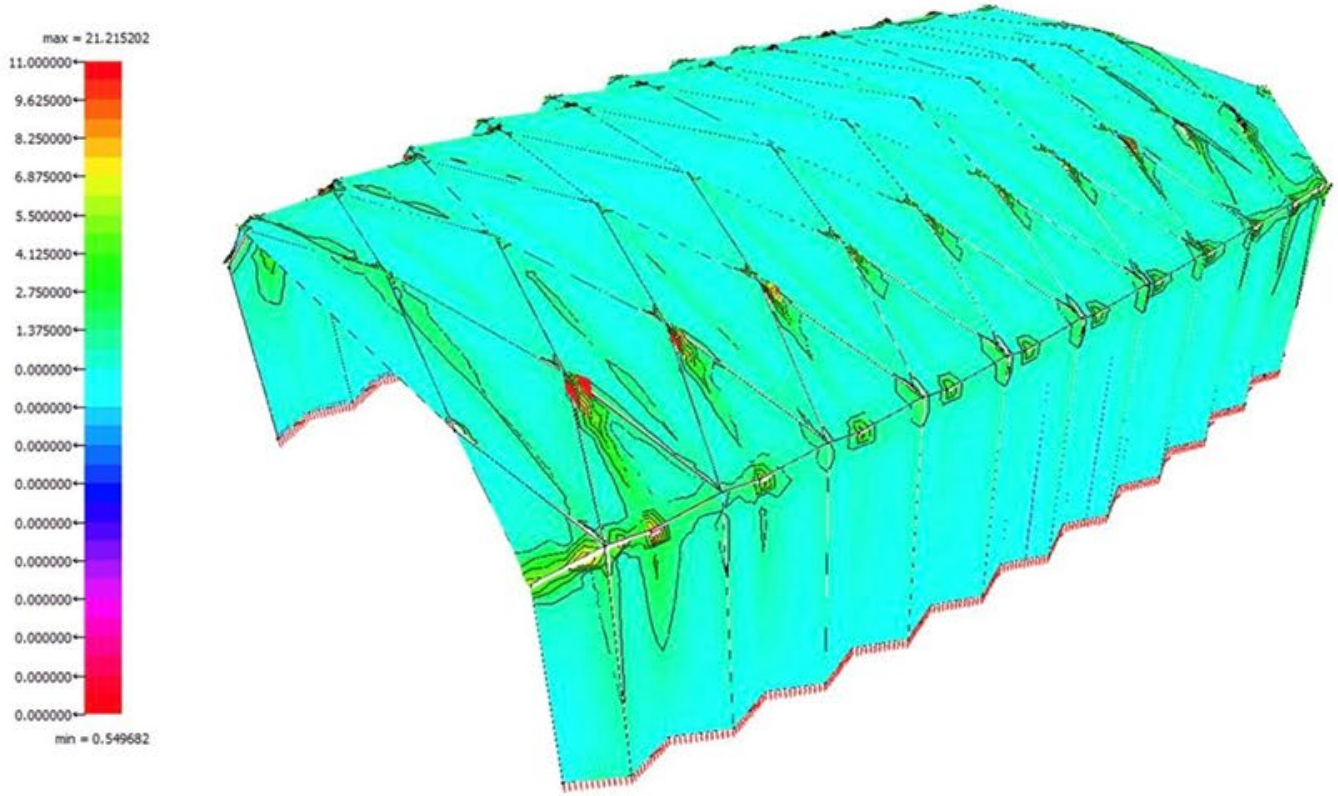
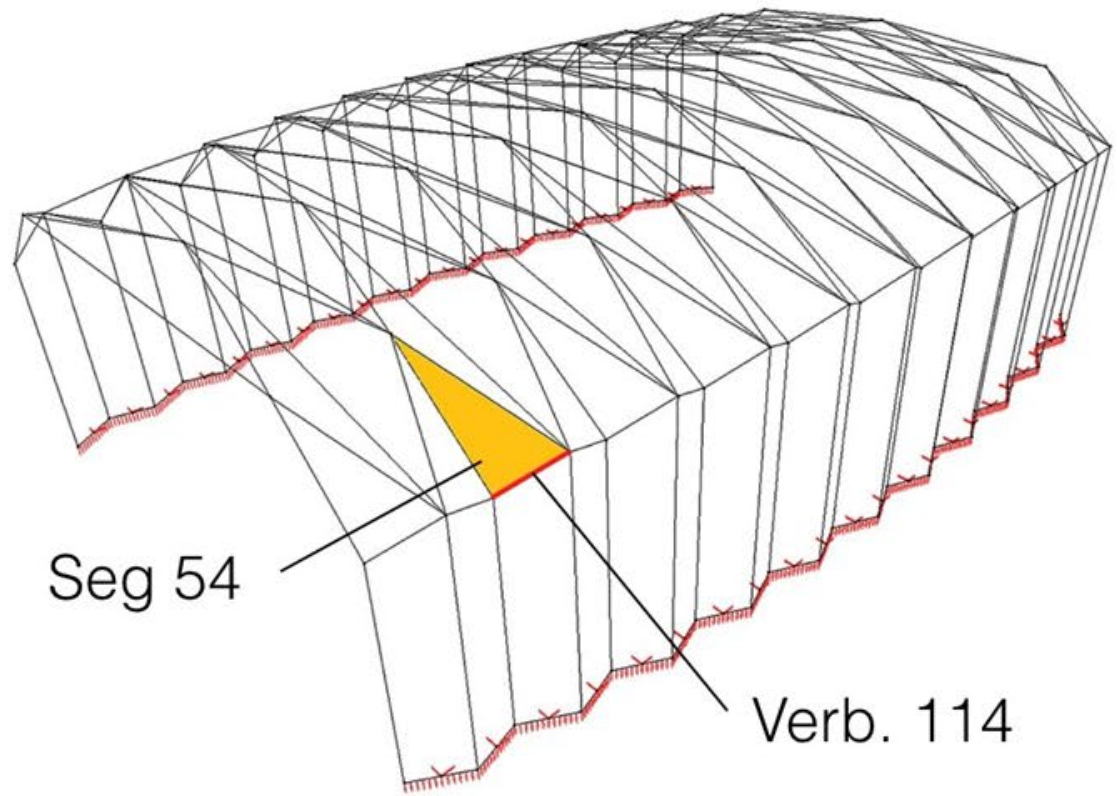
Statische Berechnungen mit 1-schichtigem Modell





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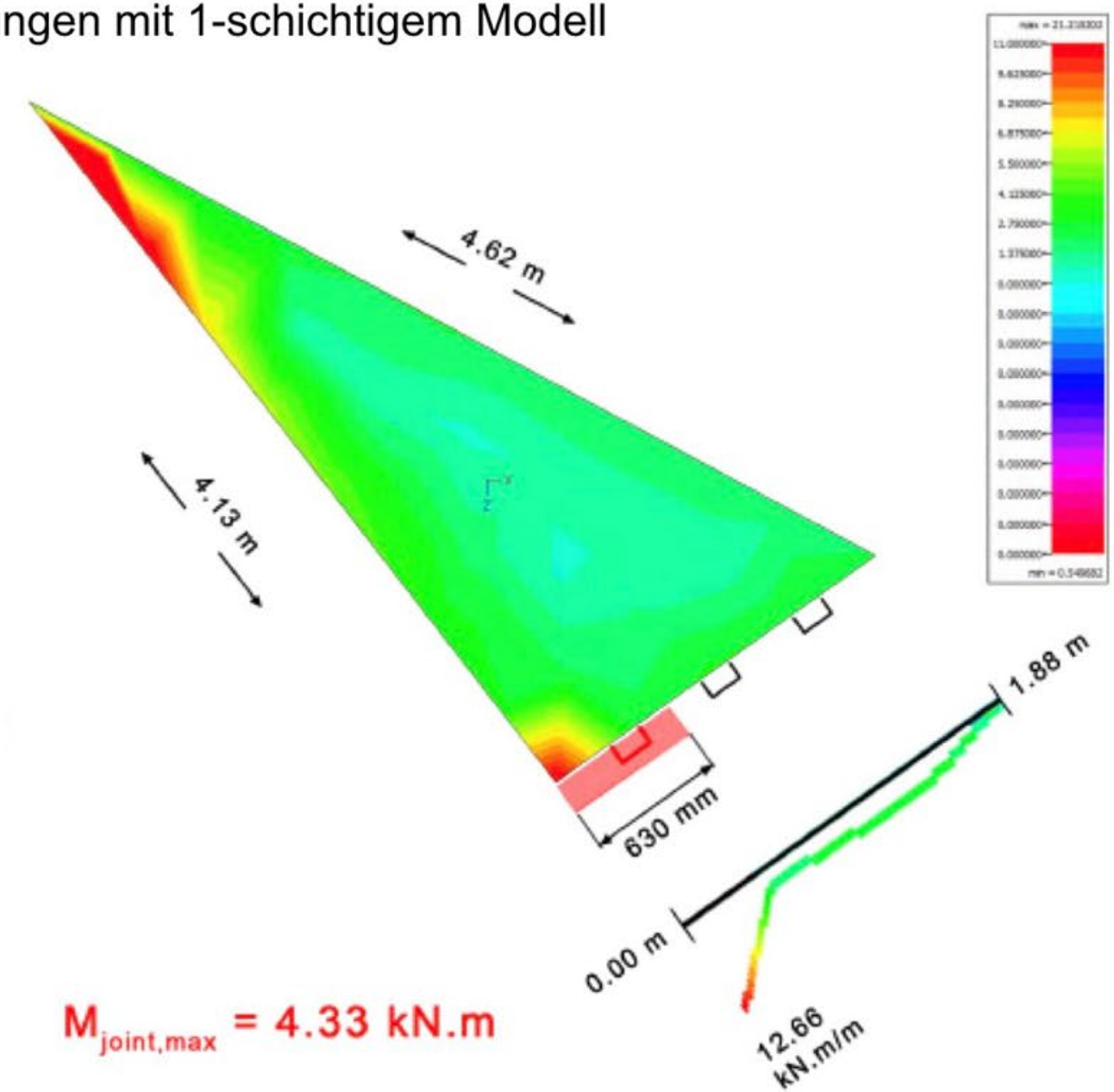
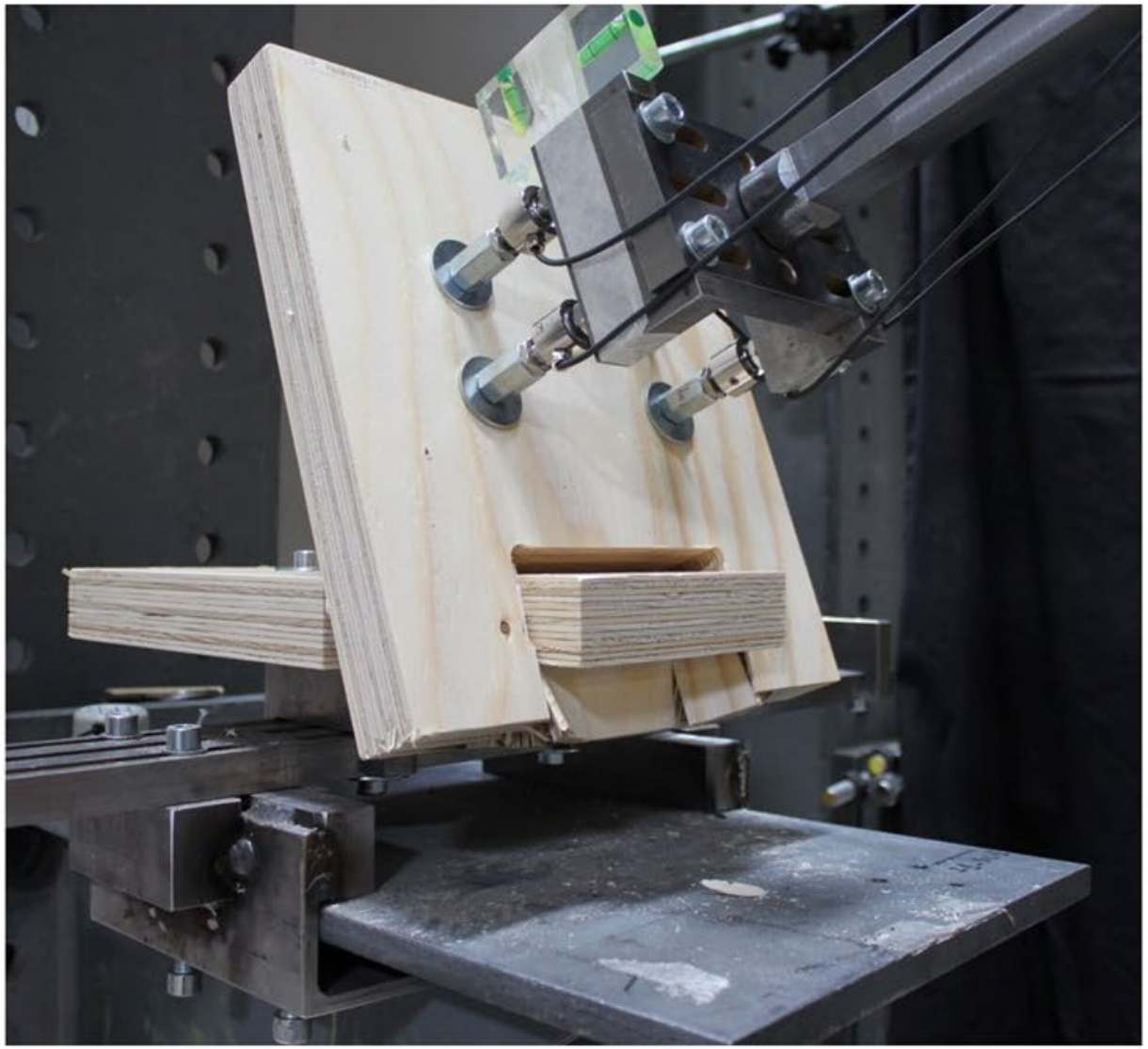
Statische Berechnungen mit 1-schichtigem Modell



$M_{joint,max}$ = 4.33 kN.m

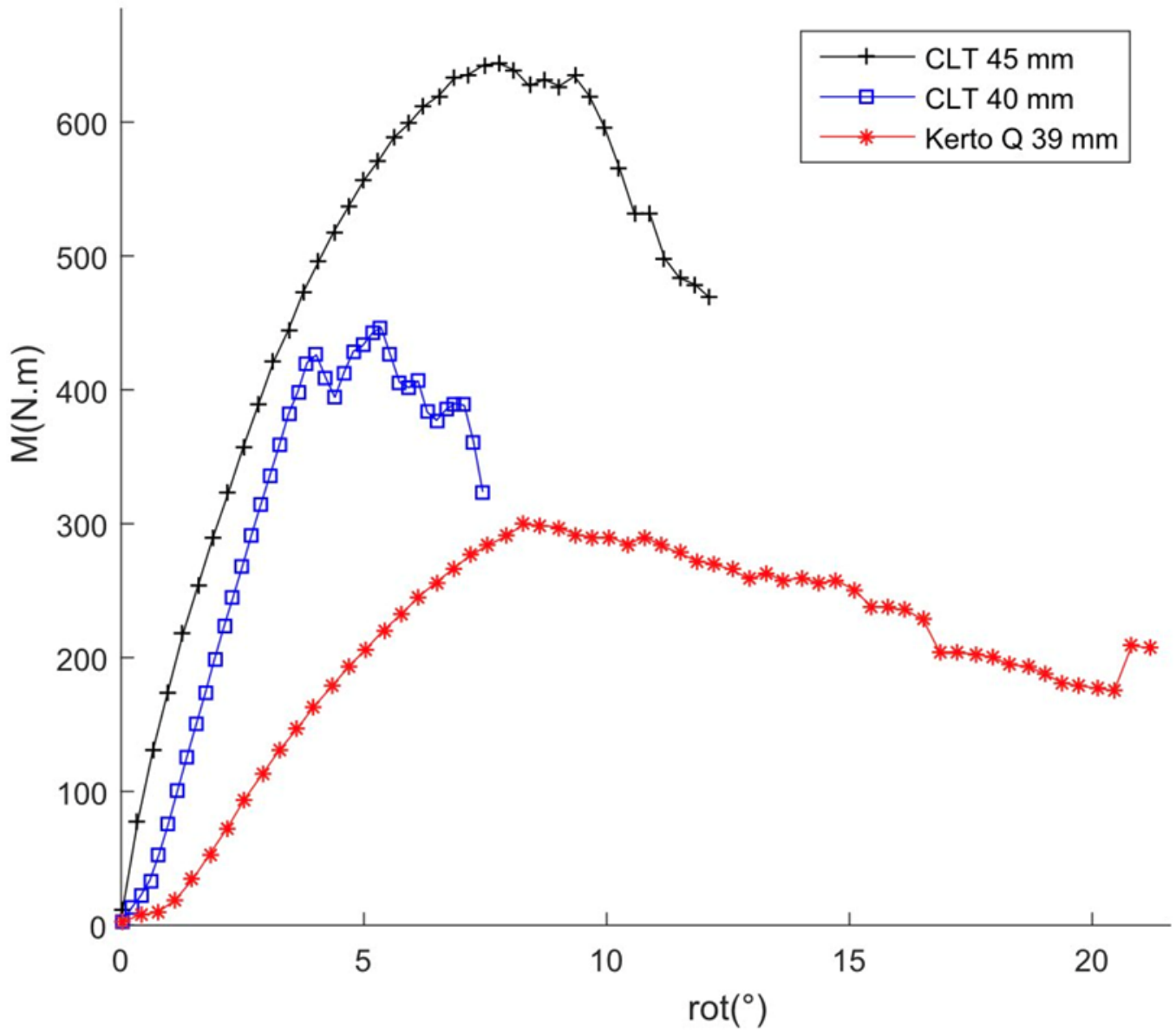
J. Gamerro, P. Coanon, C. Robeller and Y. Weinand

1-schichtiger Versuch mit verschiedenen Platten



BSP 40 mm	3	12,5 / 15 / 12,5 mm	I-I
BSP 45 mm	5	5 x 9 mm	I-I-I
FSP 39 mm	13	13 x 3 mm	II–III–III–II

1-schichtiger Versuch mit verschiedenen Platten



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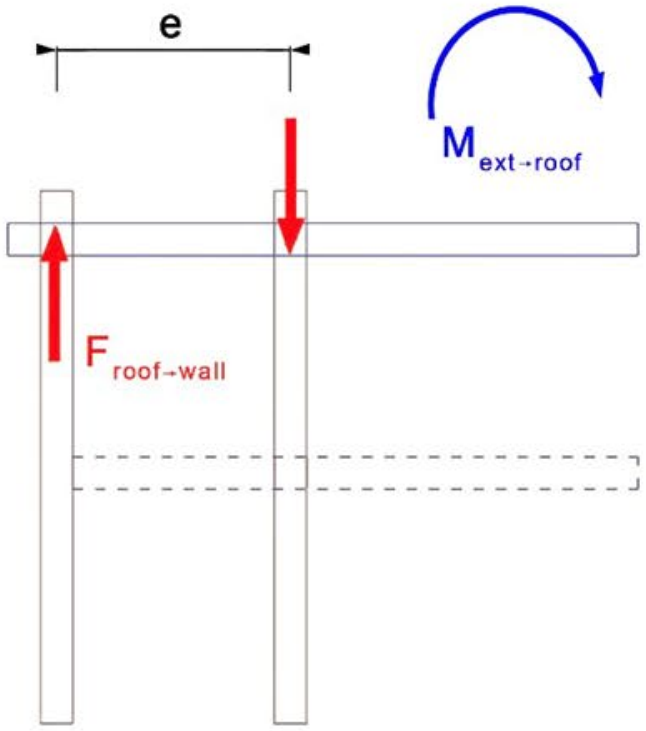
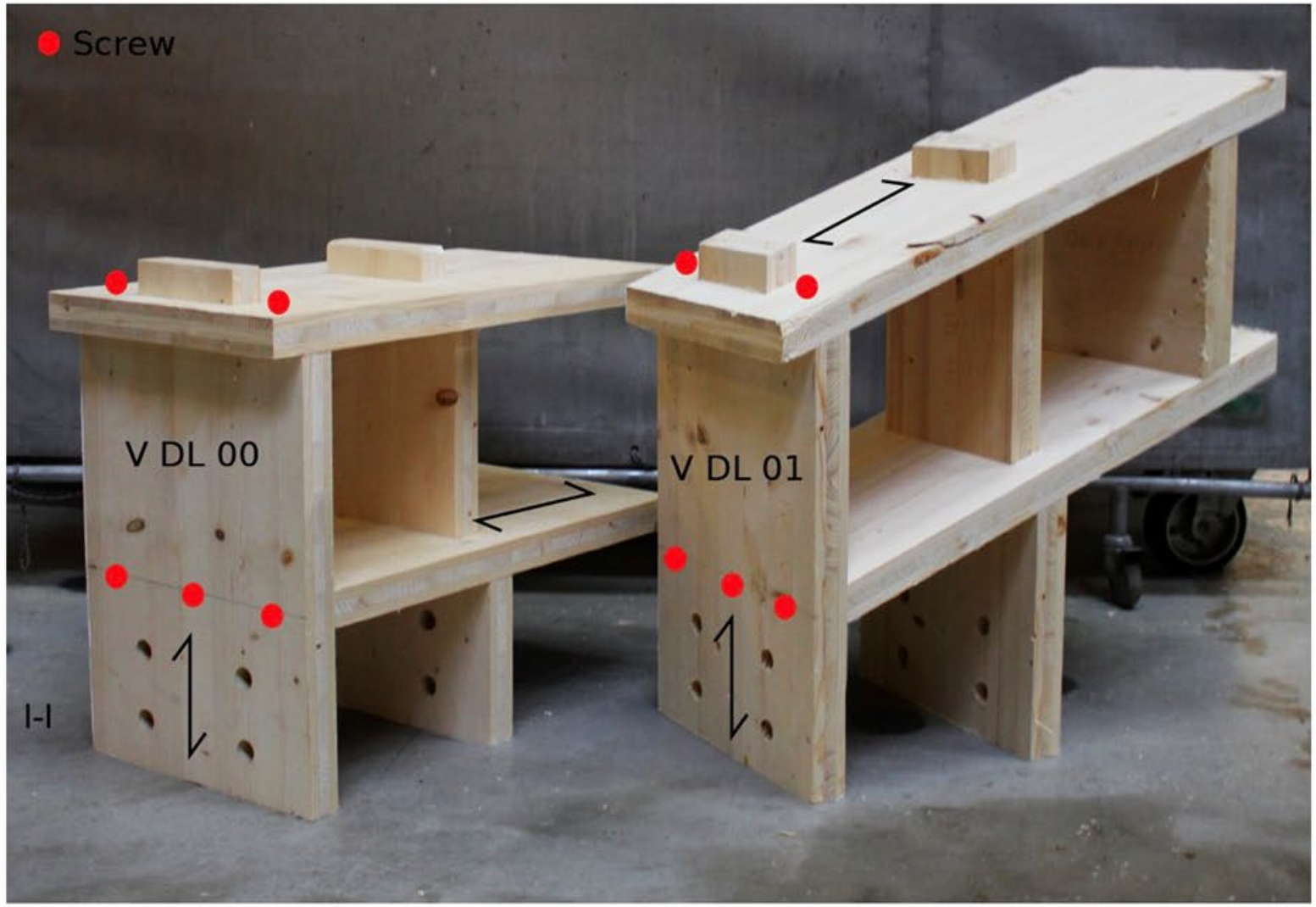
2-schichtiger Versuch mit 40mm / 45mm BSP



T_{Plate} 45 mm

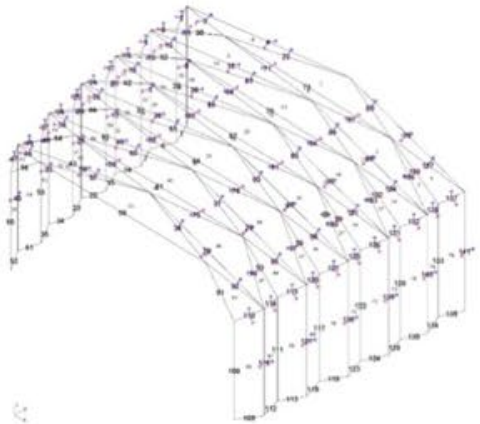
$T_{Structure}$ 300 mm



J. Gamerro, P. Coanon, C. Robeller and Y. Weinand

Digitale Kette

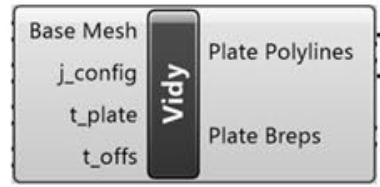
3D Polynetz



Excel Konfiguration

z.b. Verbindungstyp, Vorfertigung od. Baustelle?

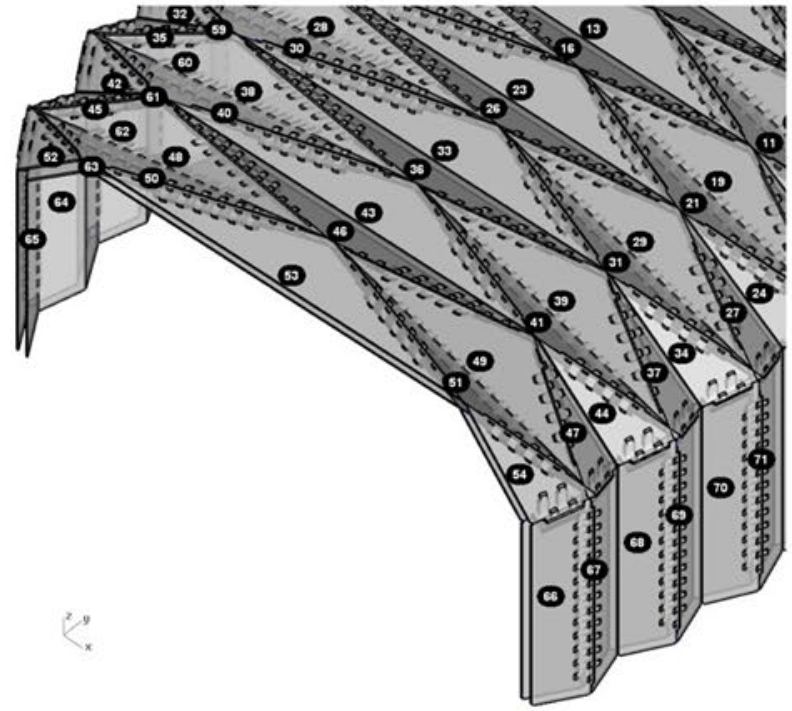
CAD Plugin



(94 KB)

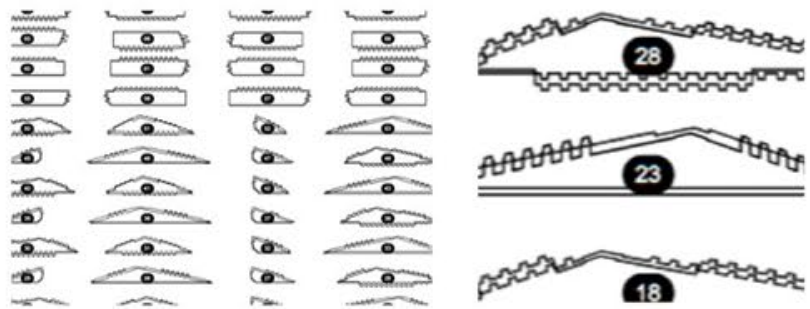
3D für FEM

3D Platten



	A	B	C	D	E	F	G	H	I
64	63	regl	pos	-0.029189	0.831696	0.554464	0.444577	-0.813043	0.37
65	64	vcon	neg	0	0	0	0	0	
66	65	regl	pos	-0.025648	-0.87022	0.491995	0.424045	0.788552	0.44
67	66	regl	pos	-0.028438	0.837616	0.545518	0.407979	-0.841577	0.35
68	67	vcon	neg	0	0	0	0	0	
69	68	regl	pos	-0.026104	-0.863279	0.504052	0.394982	0.825341	0.40
70	69	regl	pos	-0.027735	0.844041	0.535561	0.382104	-0.856817	0.3
71	70	vcon	neg	0	0	0	0	0	
72	71	regl	pos	-0.026577	-0.85685	0.514881	0.375845	0.848788	0.37
73	72	regl	pos	-0.027078	0.850921	0.524596	0.372159	-0.858575	0.35
74	73	vcon	neg	0	0	0	0	0	
75	74	regl	pos	-0.030837	0.821759	0.568999	0.514992	-0.72264	0.46
76	75	regl	pos	-0.024697	-0.885975	0.463074	0.477475	0.683106	0.55
77	76	regl	neg	-0.190671	0.772317	-0.605947	-0.21025	-0.713686	-0.66
78	77	regl	pos	-0.02999	0.826367	0.562333	0.483628	-0.772441	0.41
79	78	regl	pos	-0.025188	-0.87775	0.478456	0.454764	0.740035	0.49
80	79	regl	neg	-0.167528	0.821766	-0.544643	-0.186508	-0.773017	-0.60
81	80	regl	pos	-0.029189	0.831696	0.554464	0.444577	-0.813043	0.37
82	81	regl	pos	-0.025648	-0.87022	0.491995	0.424045	0.788552	0.44
83	82	regl	neg	-0.14883	0.85724	-0.492939	-0.165137	-0.820717	-0.54
84	83	regl	pos	-0.028438	0.837616	0.545518	0.407979	-0.841577	0.35
85	84	regl	pos	-0.026104	-0.863279	0.504052	0.394982	0.825341	0.40

3D Platten Planar → CAD Plugin → G-Code



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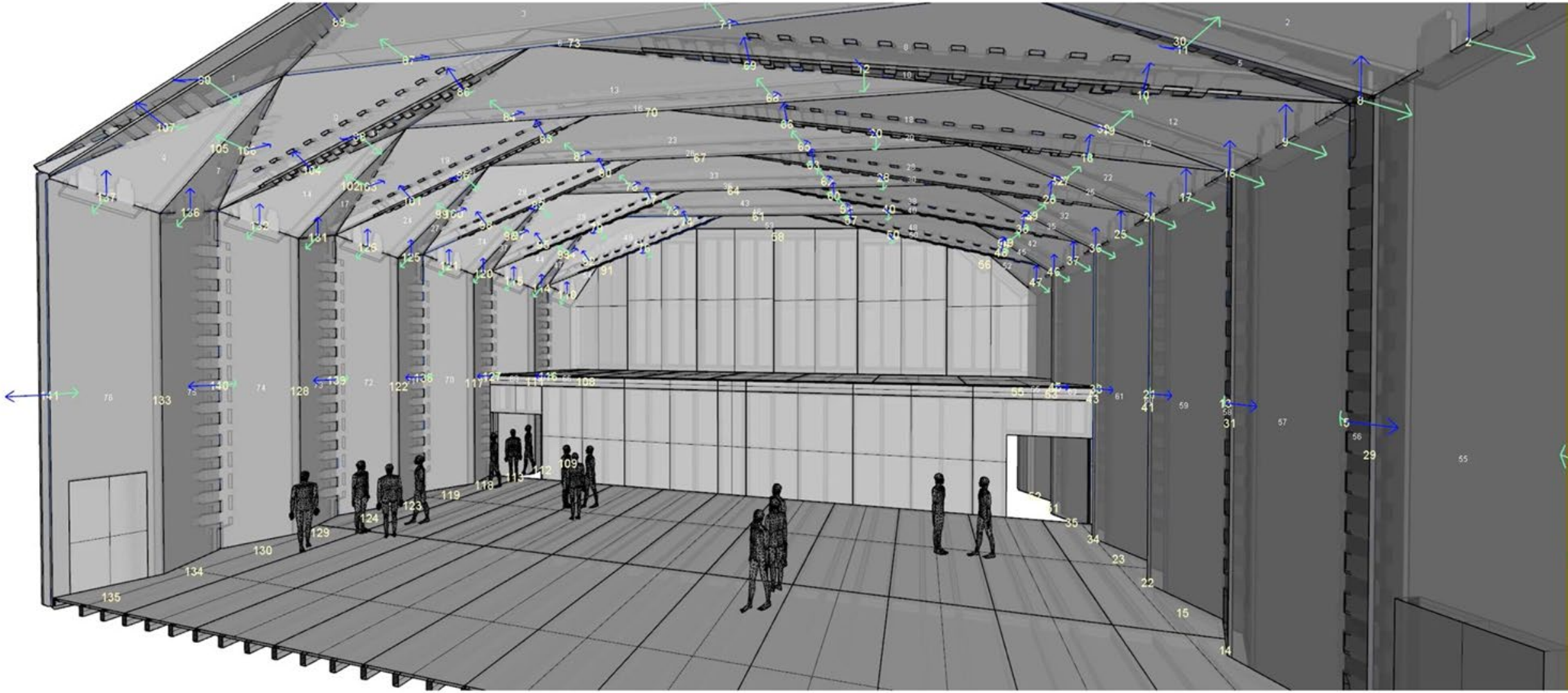
Faltwerk aus Holzplatten, 2006



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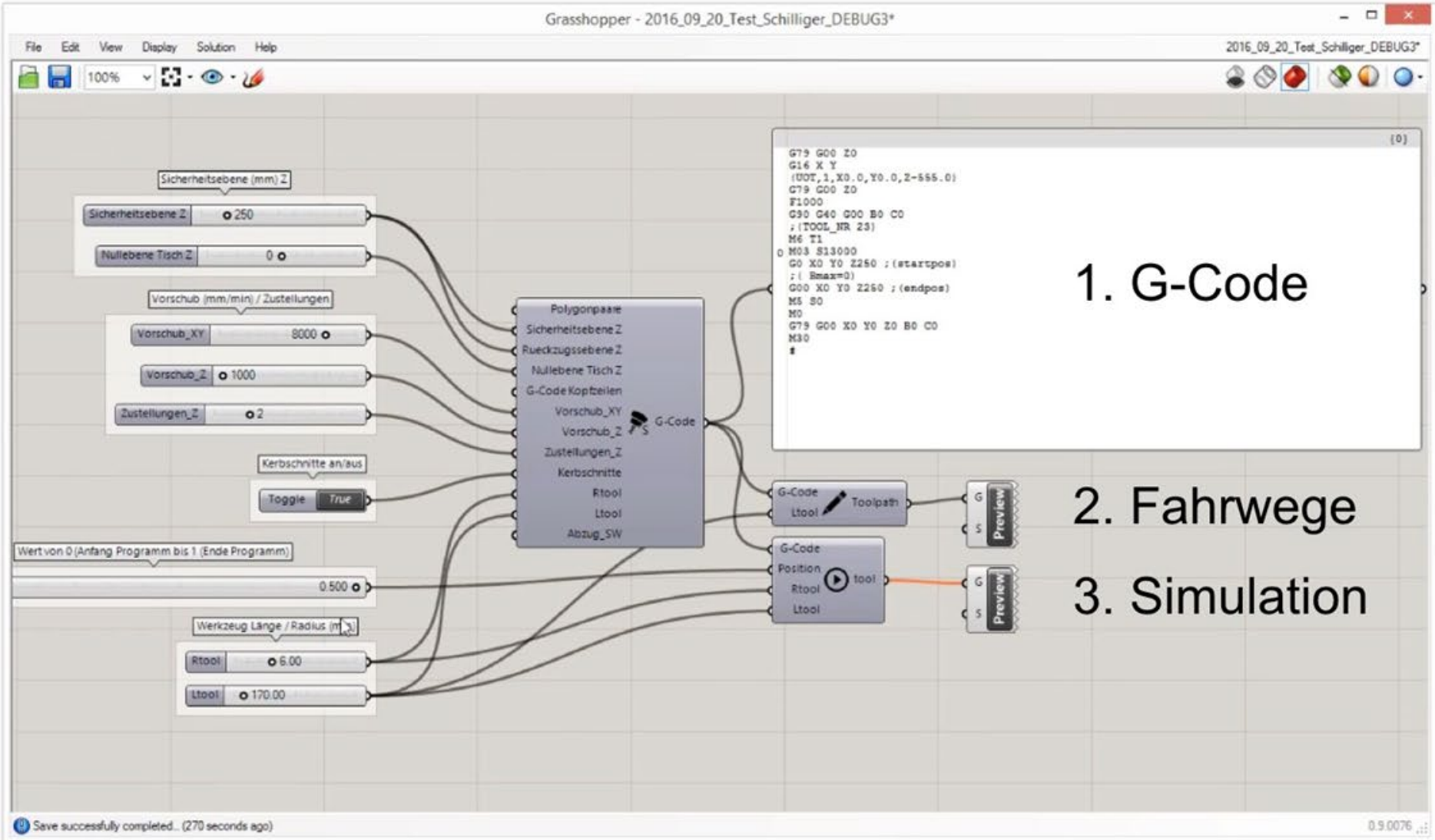
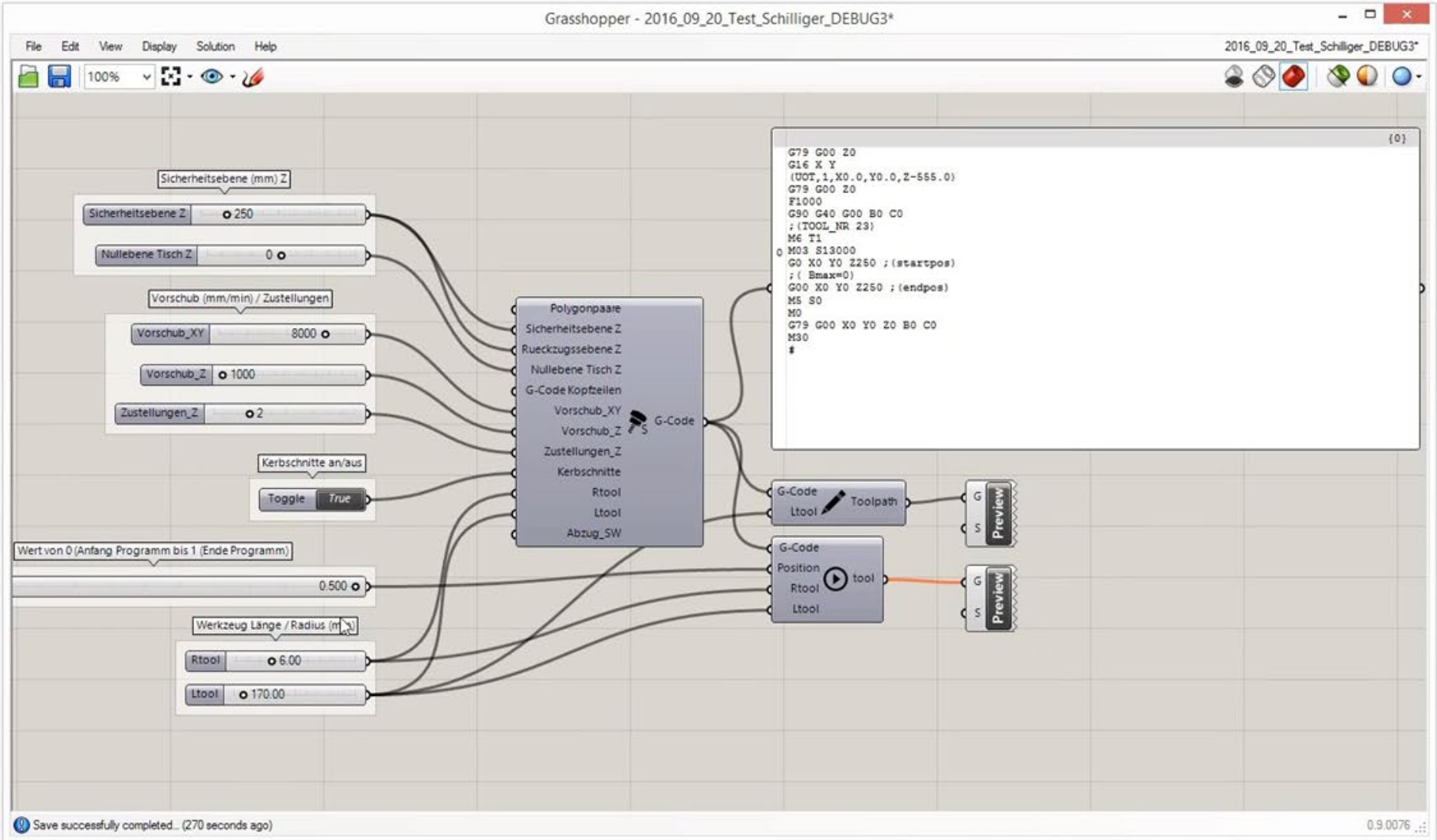
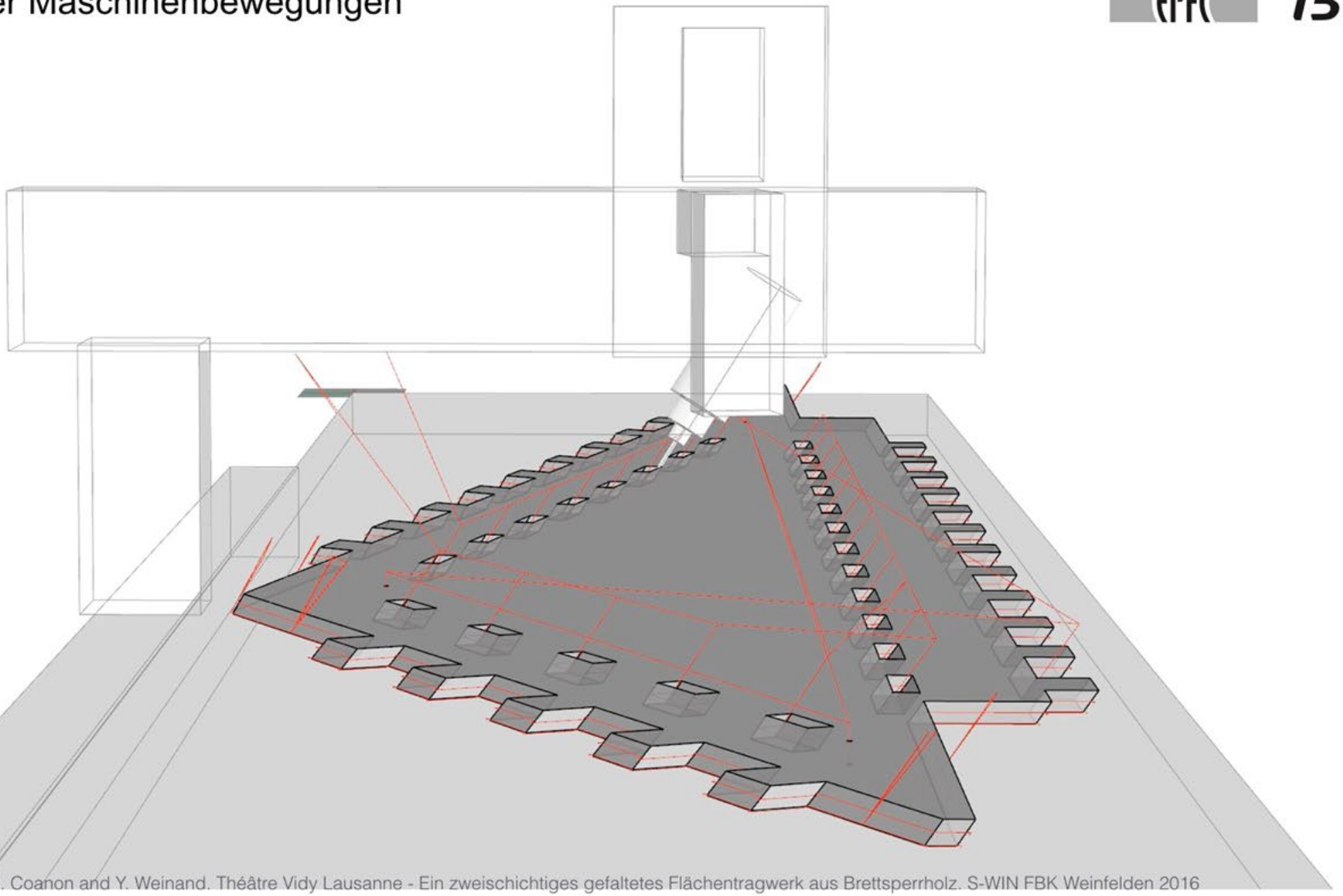
G-Code Generator Plugin



G-Code Generator Plugin



Simulation der Maschinenbewegungen



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Produktion

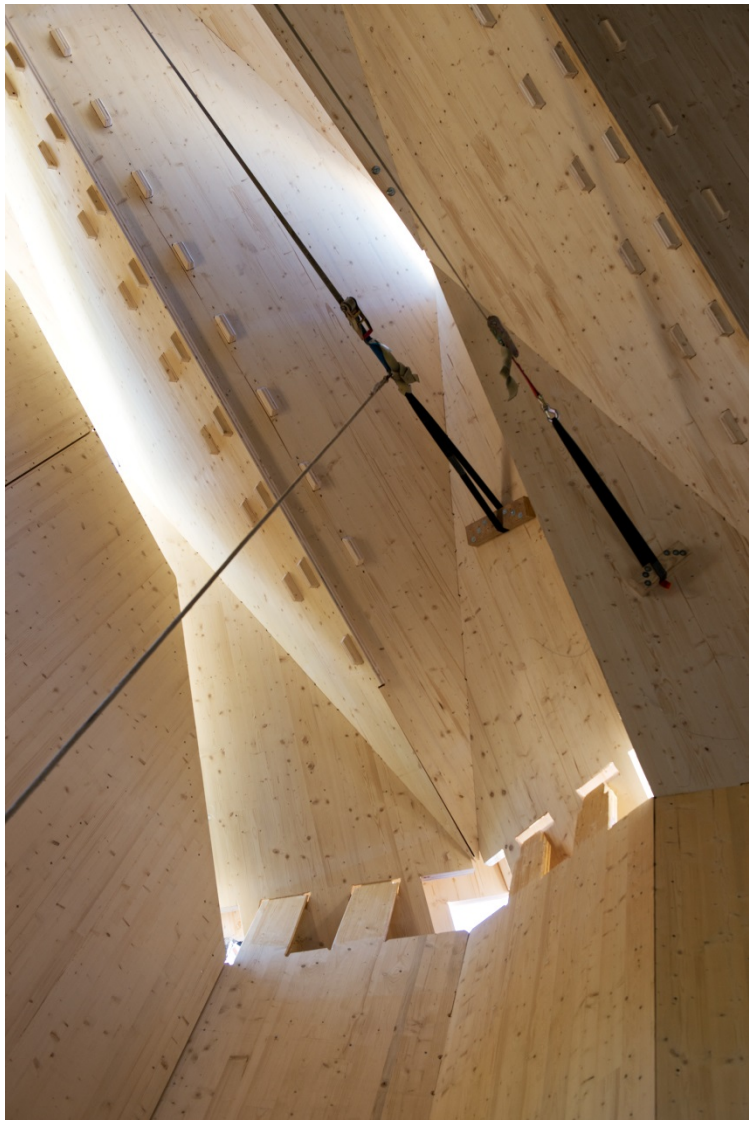
Produktion

Prefabrication- wall elements

Montage

Montage

Montage



Montage