



Mind-Bending Timber Adventures

A short journey to the world of freeform timber structures

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Martin Bender Free Form | International, Blumer-Lehmann AG



StructureCraft

ETH zürich



**Blumer
Lehmann**
Timber construction | Engineering

swipe



Where did I grow up?

No votes



You design/build/study timber structures:

No votes

1 Exclusively

2 Most of the time

3 Sometimes

4 Rarely

5 Never

Why did you come here?

No votes

1

Timber > Steel > Concrete

Vote

2

The freeform topic looked interesting

Vote

3

The other rooms filled up already

Vote

4

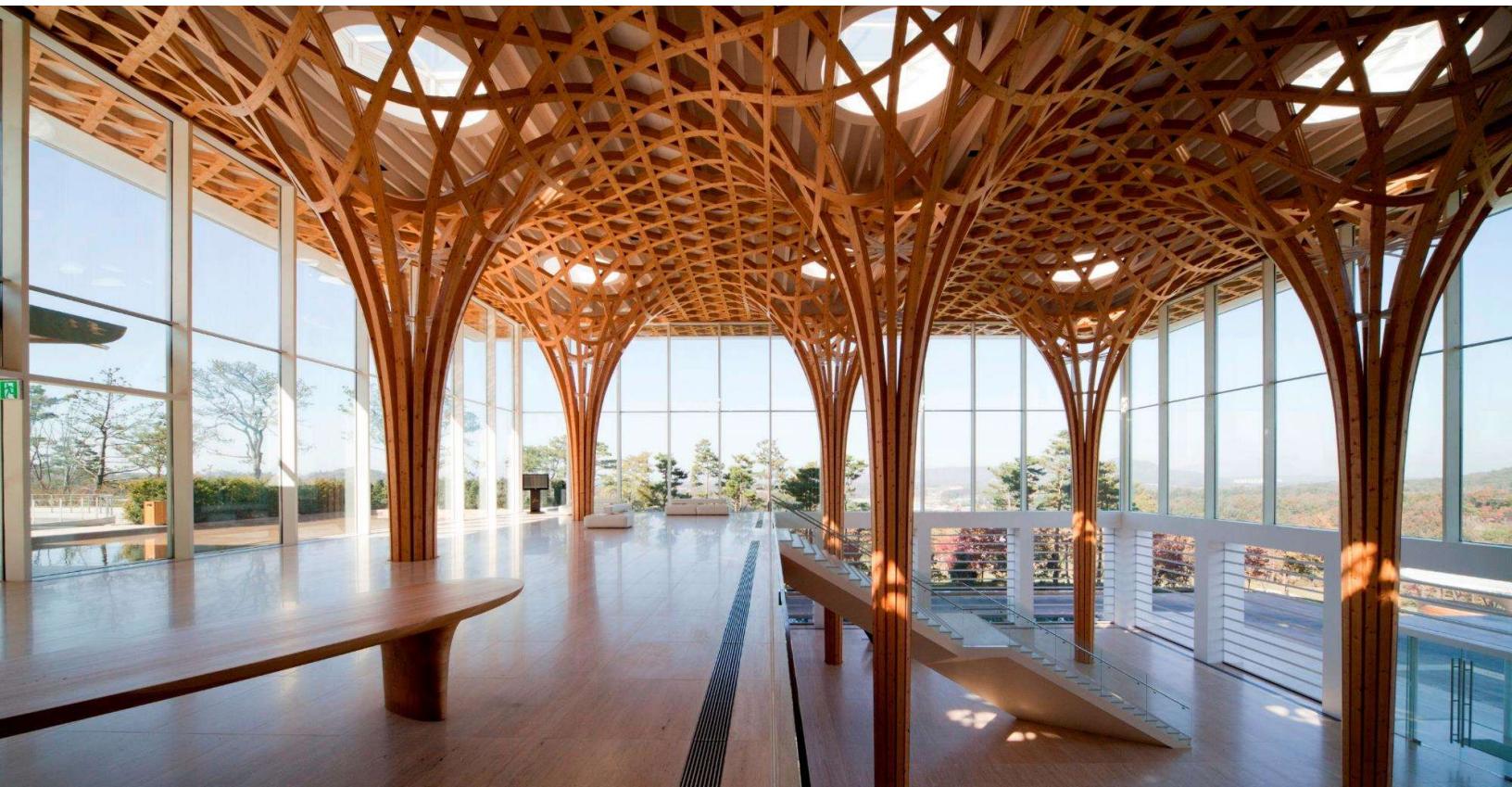
I don't know

Vote

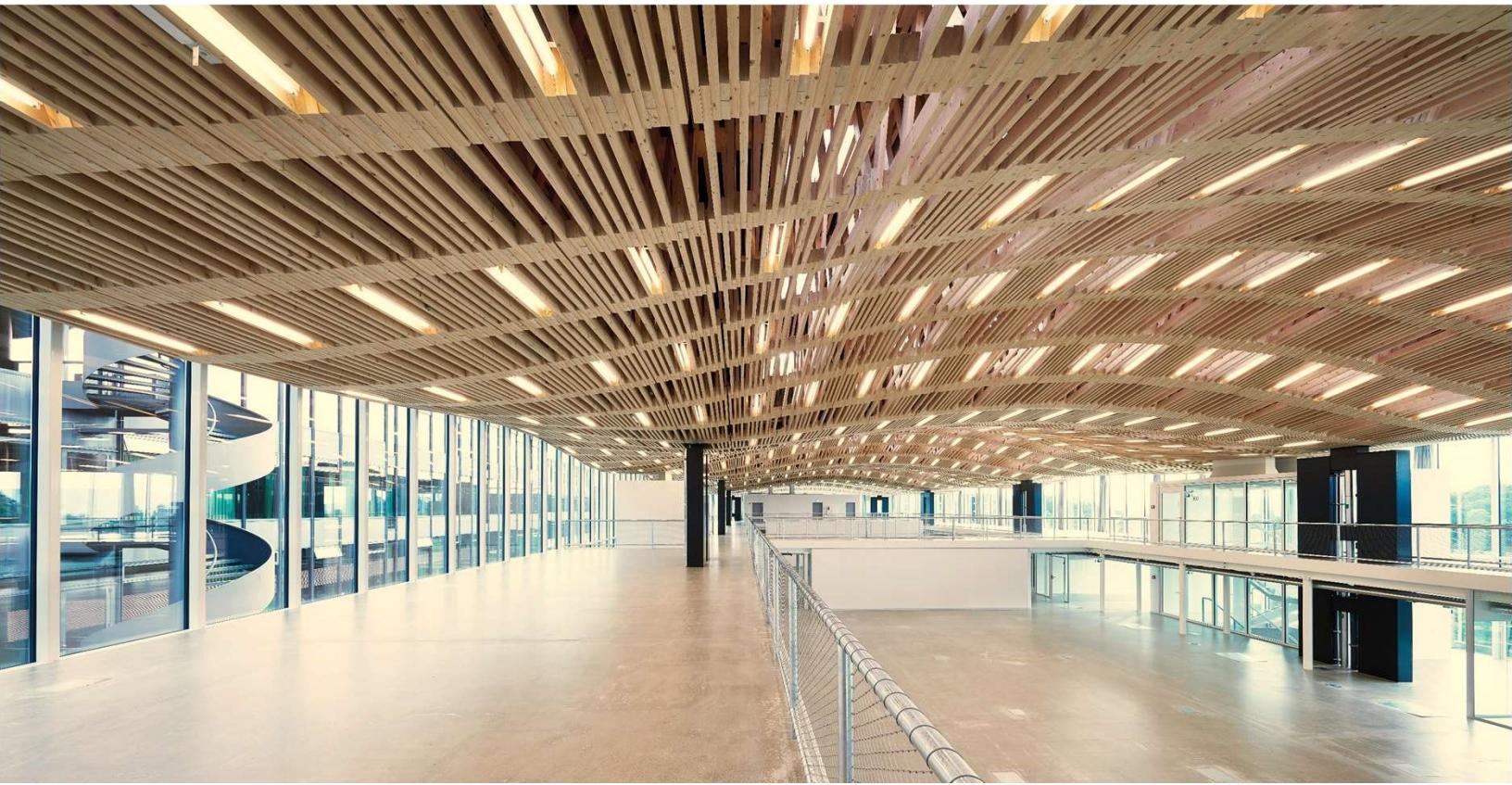
Haelsey Nine Bridges Golf Club, South Korea

Blumer
Lehmann
Holzbau | Engineering

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Arch_Tec_Lab, ETH Zürich



Kilden Performing Arts Centre, Norway

Blumer
Lehmann
Holzbau | Engineering

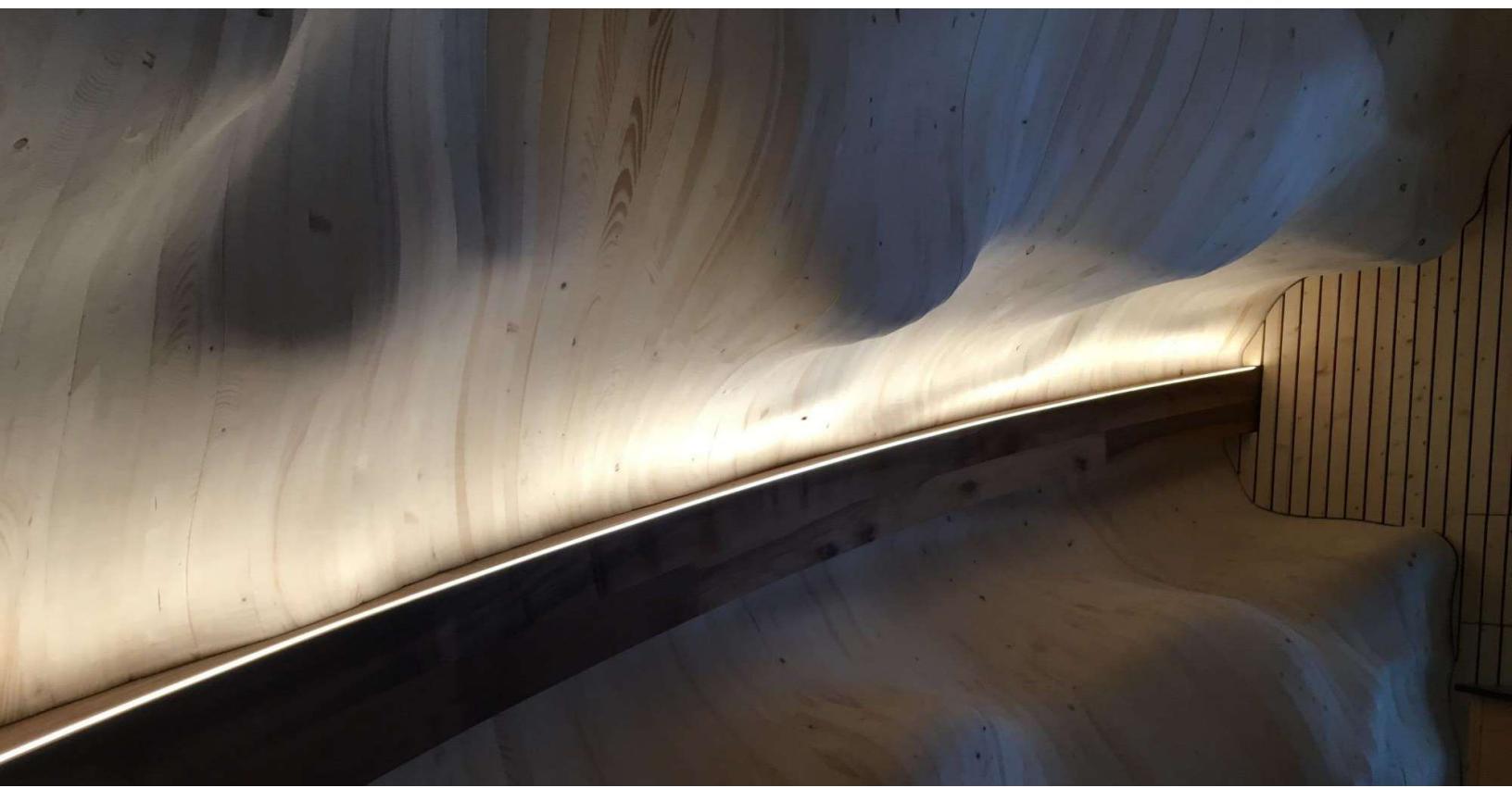
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Talstation Staubbahn, Frümsen SG

 Blumer
Lehmann
Holzbau | Engineering

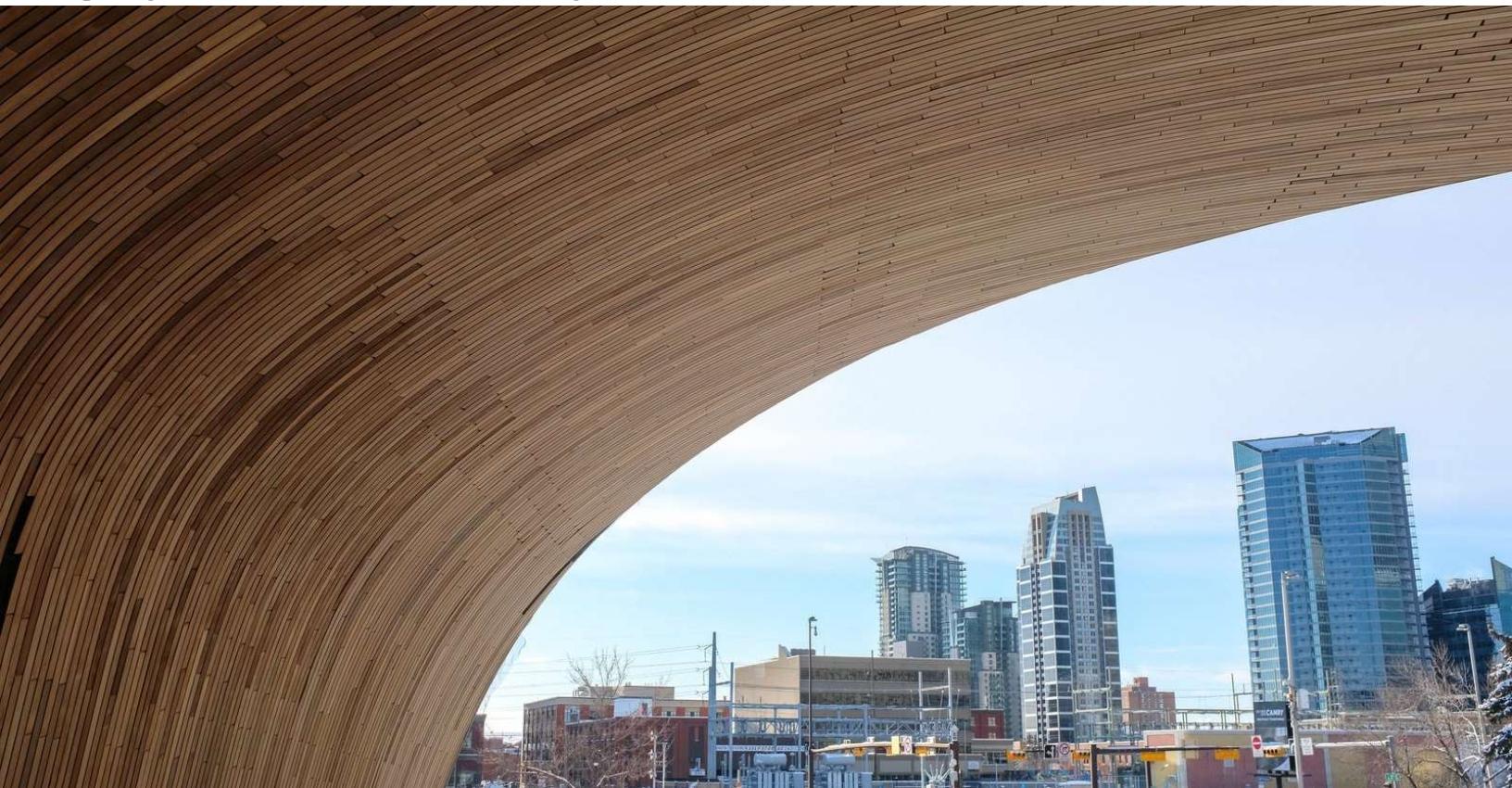
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Calgary New Central Library, Alberta, Canada

Blumer
Lehmann
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Hunting Pavilion, Ohio, USA

 Blumer
Lehmann
Holzbau | Engineering

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	«Normal» Project	Freeform Project
Geometry	Mostly regular	
Software used	Any	
Design Phase	Typical	
Construction	Mostly on site	
Risk	Low	
Reward	Medium	
Fun	Type 1	

	«Normal» Project	Freeform Project
Geometry	Mostly regular	Complex
Software used	Any	Parametric
Design Phase	Typical	Extremely detailed
Construction	Mostly on site	Mostly during design
Risk	Low	High
Reward	Medium	Very High
Fun	Type 1	Type 2

Timber Bending

$$R = 200 \times t$$

What is $R = 200 \times t$?

No votes

1

Time vs resistance to bending

0

2

Lamella thickness vs bending radius

0

3

Tension vs bending radius

0

4

No idea

0

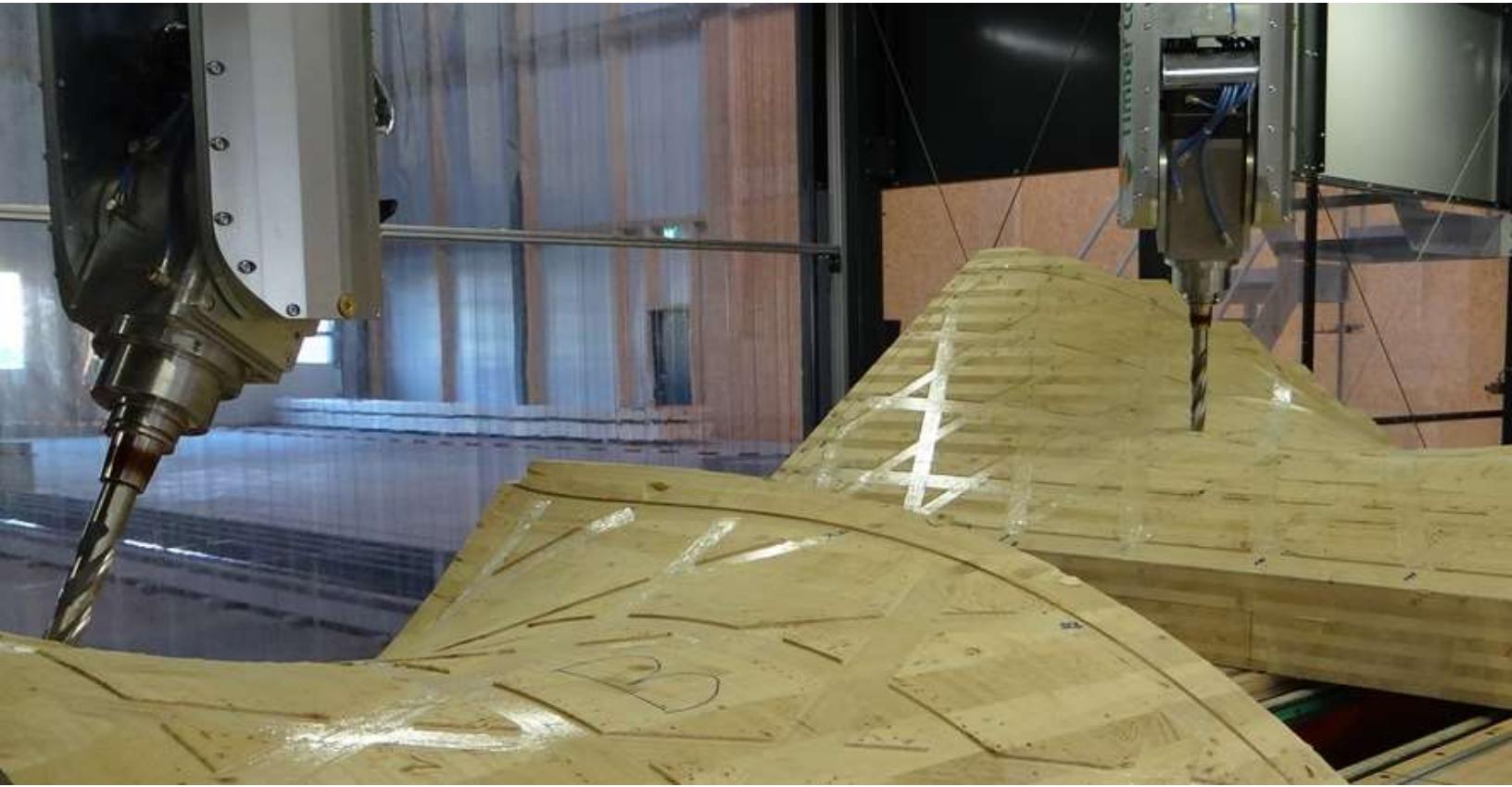
Steam Bending



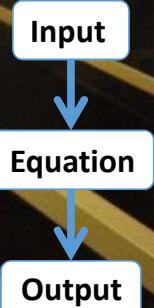
2D CNC



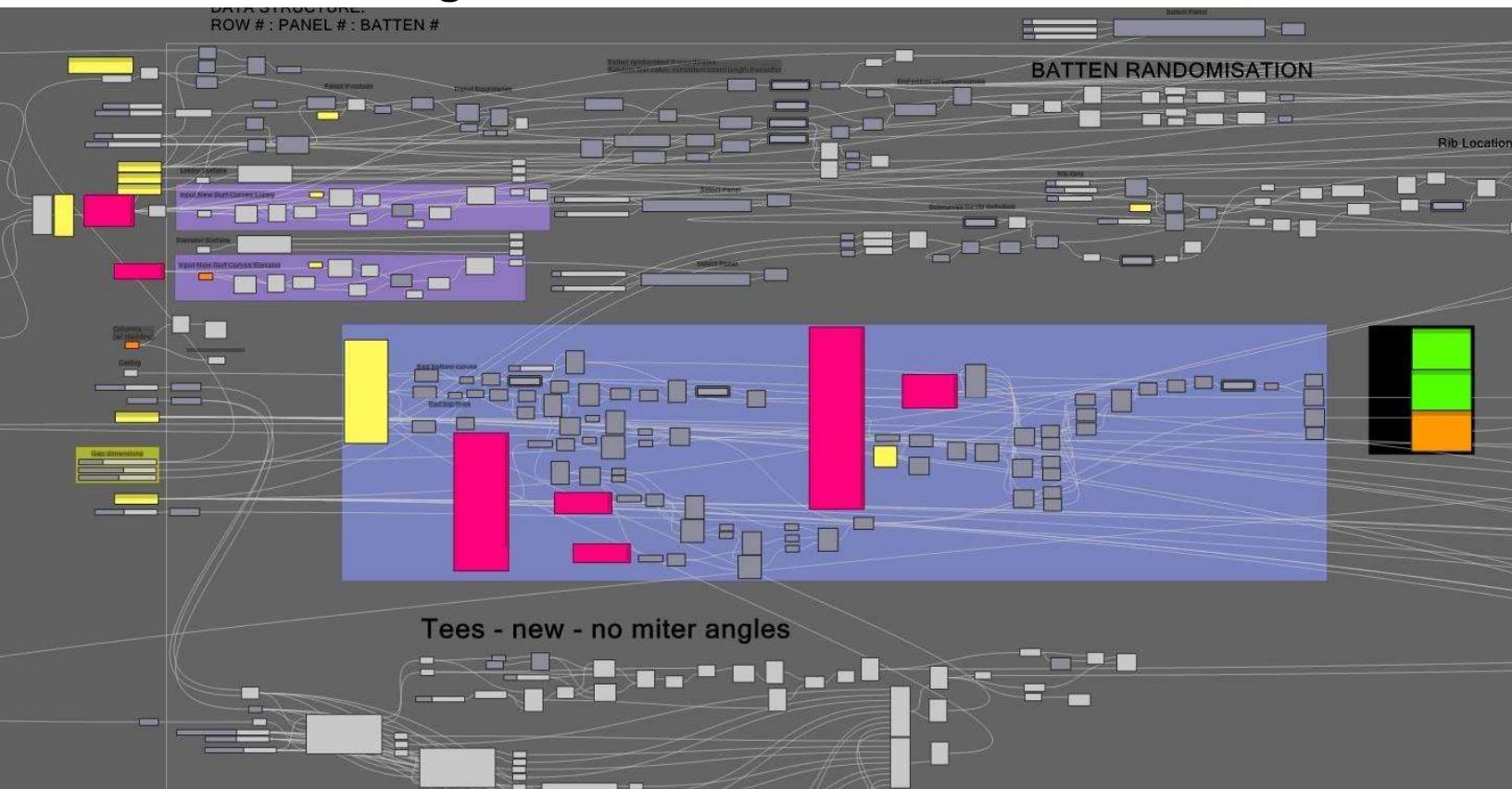
3D CNC



Parametric Modelling



Parametric Modelling Tools



Waiea Feature Ceiling, Honolulu, Hawai'i

Blumer
Lehmann
Holzbau | Engineering

ETH zürich



WARD VILLAGE
Howard Hughes
THE HOWARD HUGHES CORPORATION



WCi ARCHITECTURE

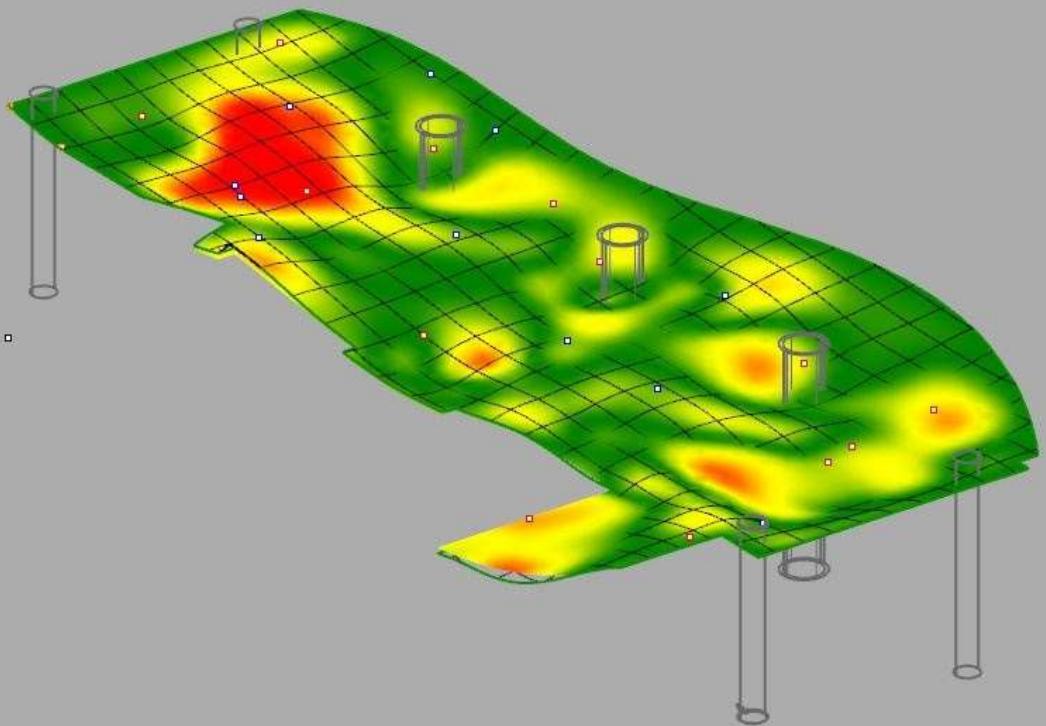
NORDIC PCL
CONSTRUCTION

StructureCraft

850m²

<1 year

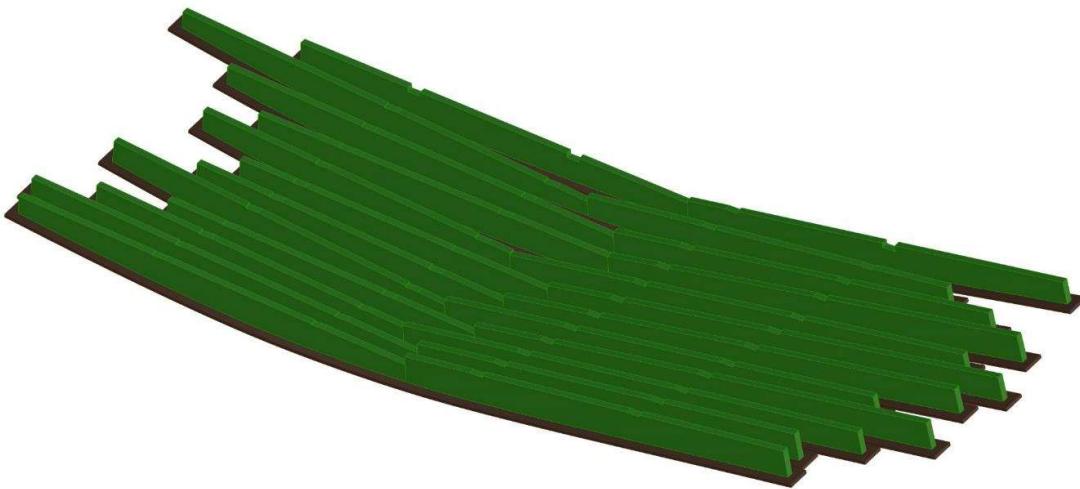
2000 pieces



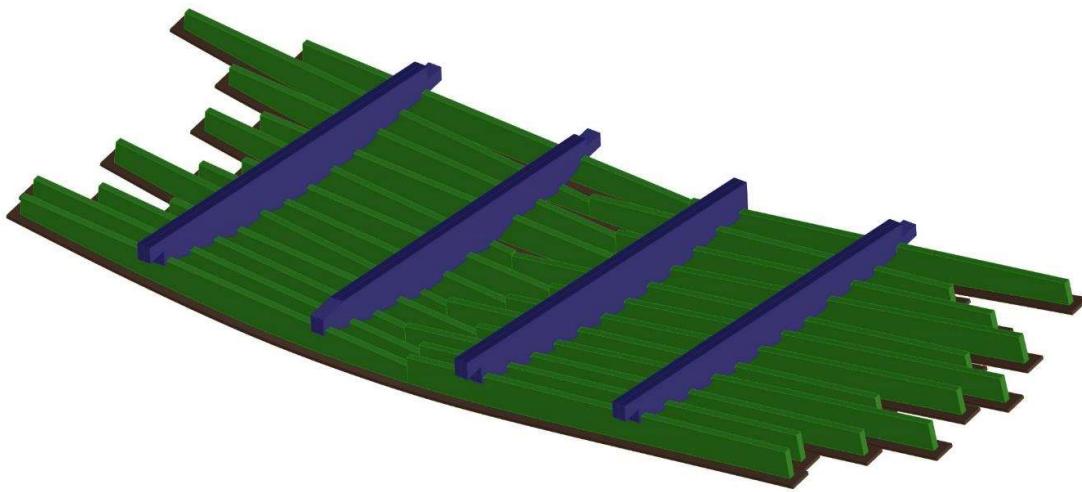
Panelisation



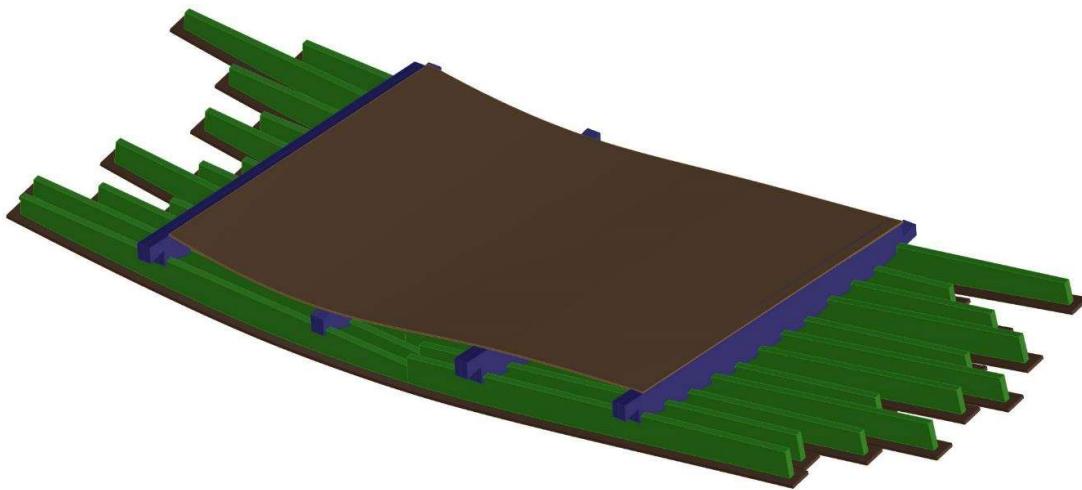
Panelisation



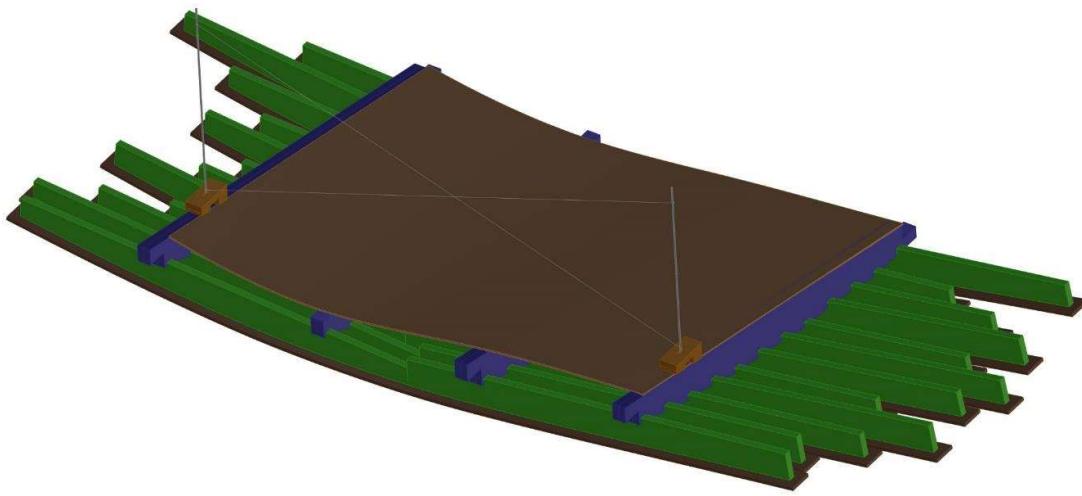
Panelisation



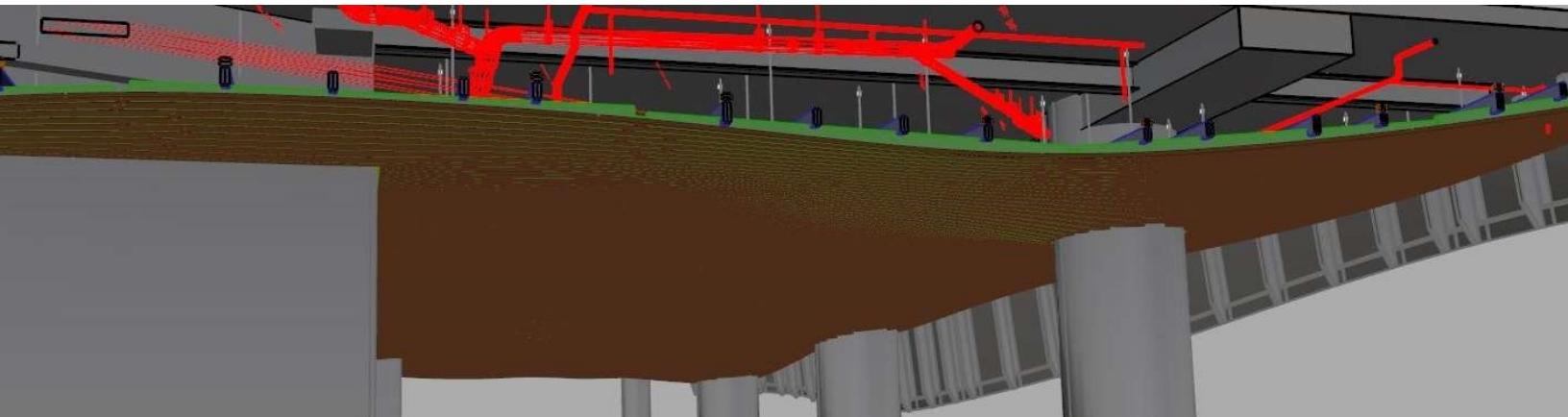
Panelisation



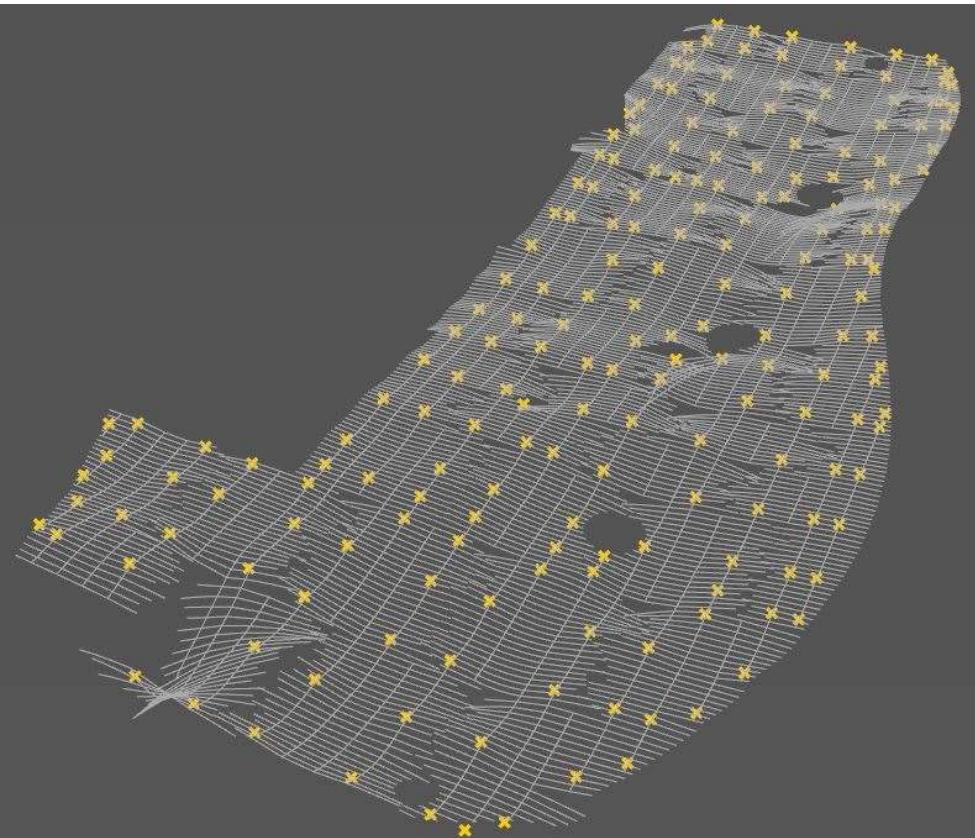
Panelisation



MEP Coordination



Parametric Structural Analysis

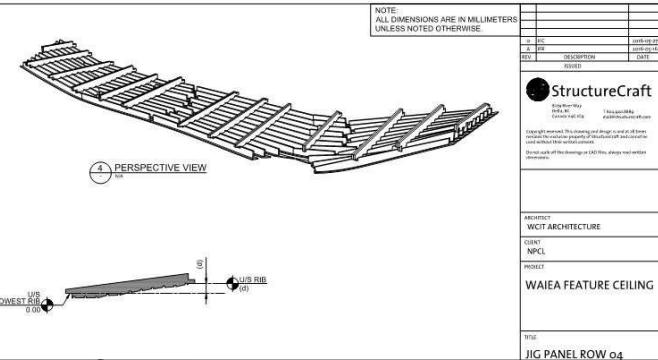
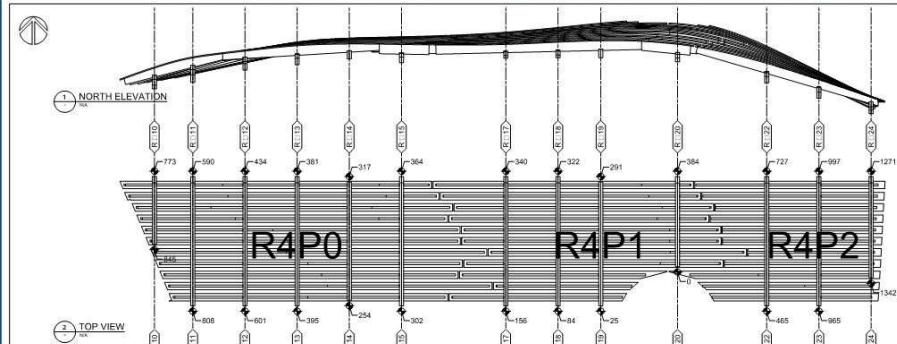


Rhinoceros®
modeling tools for designers



Karamba
parametric engineering

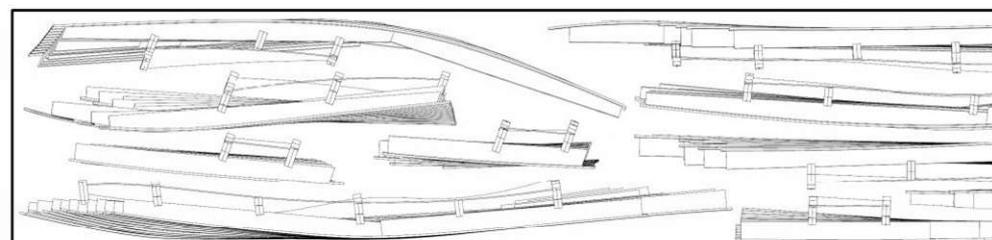
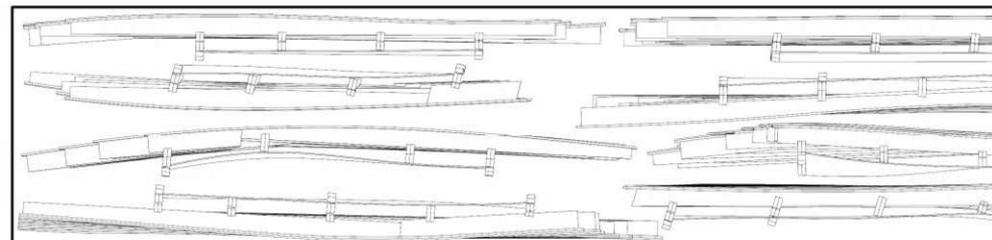
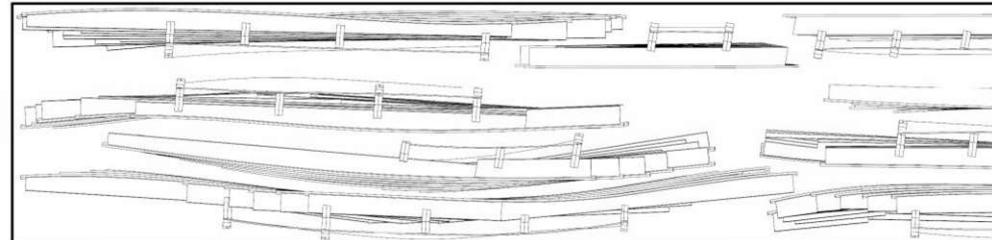
Fabrication



2x8 sets for 8ft long pieces



Transportation



Installation





Who was the happiest stakeholder in this project?

No votes



Combining tradition and innovation



Closing the Circle

Closing the circle.
We're driven to close the life cycle of wood and are therefore involved in all areas of the economic and ecological supply chain of timber. Today, we are the pioneers of innovative and sustainable timber construction.



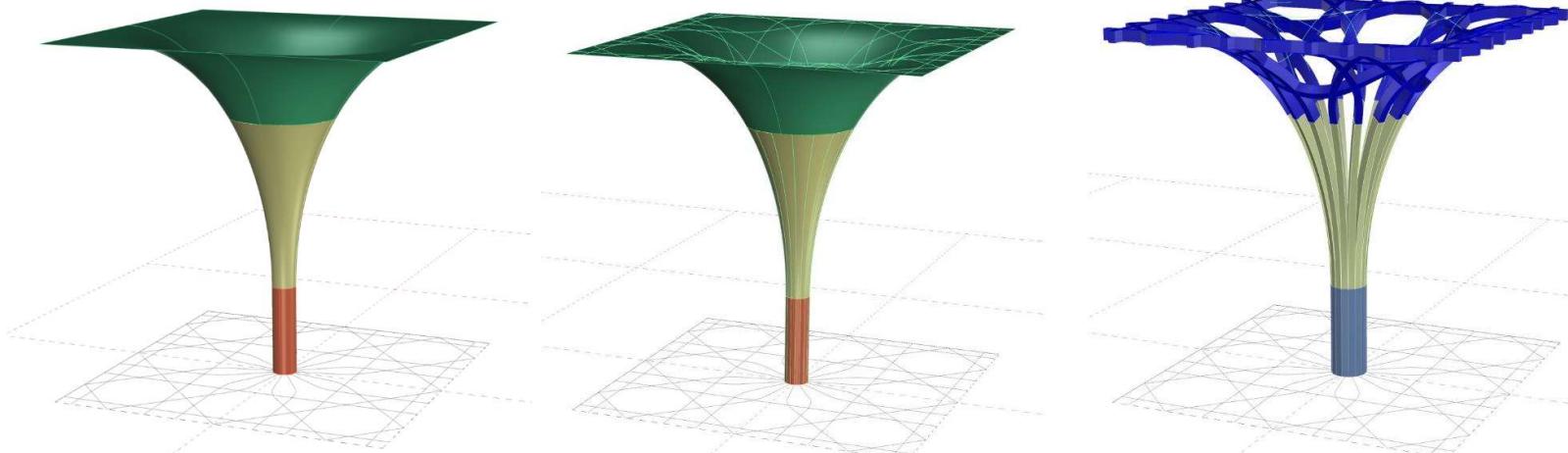
Cambridge Mosque

Blumer
Lehmann
Holzbau | Engineering

ETH zürich



Engineering Process



1st Step:

- Setting out in 2D
- To display element in 2D
- To generate Master Surface

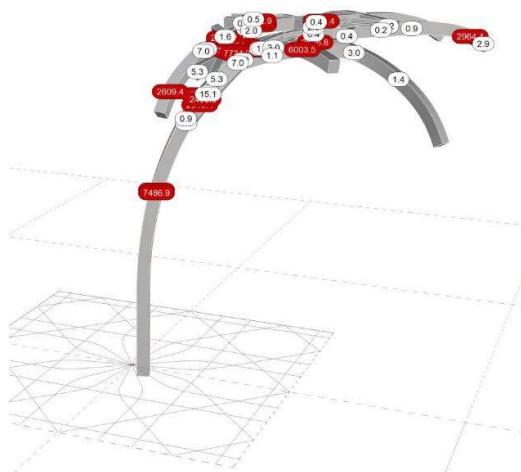
2nd Step:

- To display axis into Master Surface
- This is the basis for structural analysis

3rd Step:

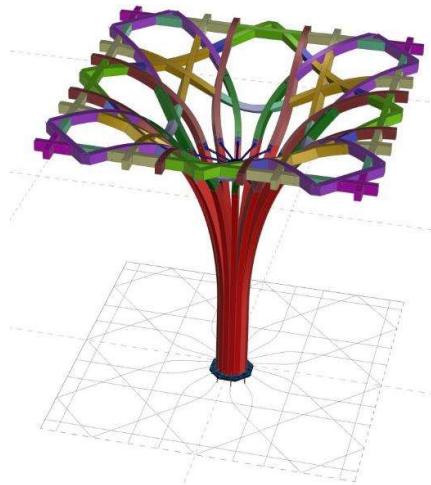
- To generate volumes related structural calculations

Engineering Process



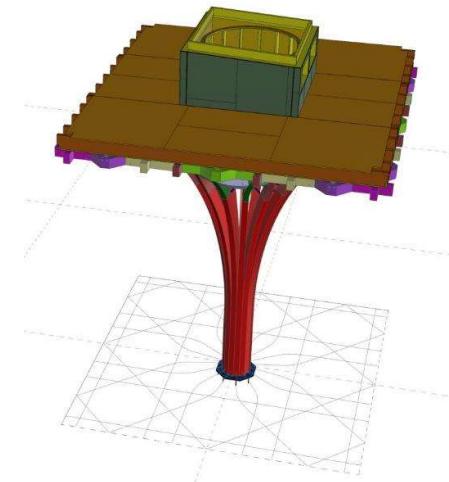
4th Step:

- To split into elements
- Analyse and define max. grain cutting angles
- Analyse radius , raw material etc.



5th Step:

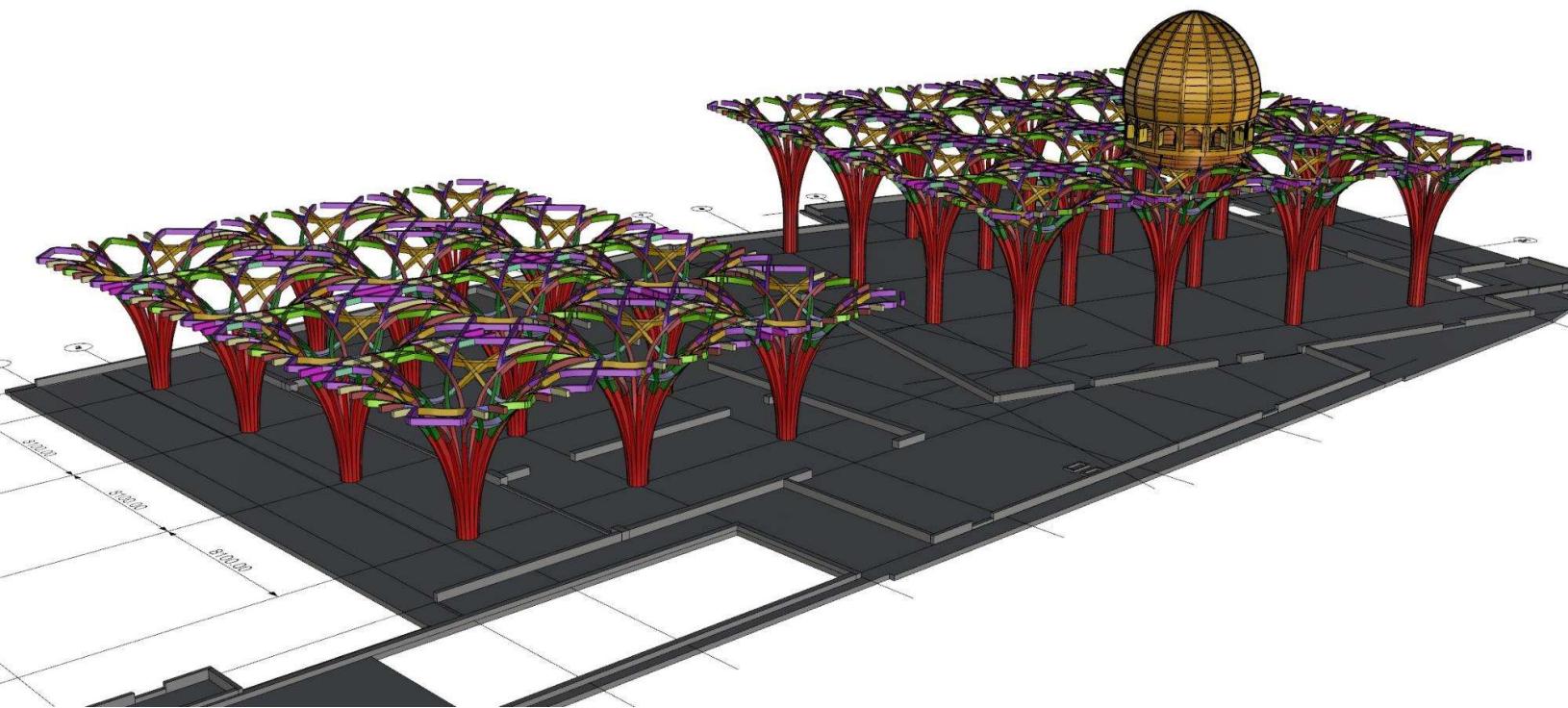
- To develop connections and knots
- To add screws, connectors into 3D Model
- To define installation method



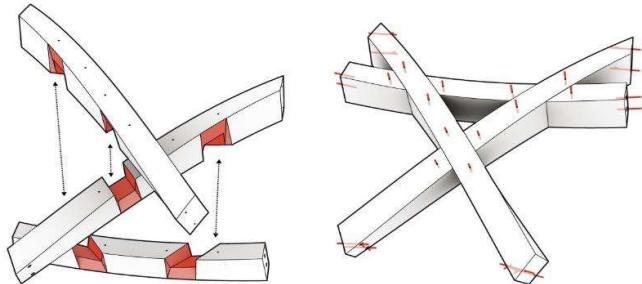
6th Step:

- To add neighbour elements as wall, roof etc.
- To coordinate interfaces with other trades

Engineering Process



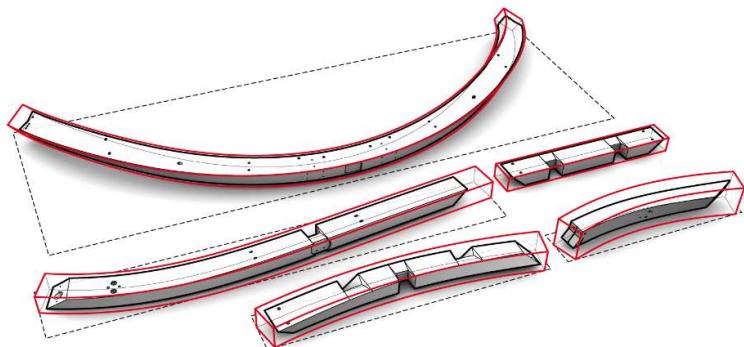
Engineering Process



Feasibility of production and installation has to be secured in a very early phase!



Engineering Process



Project with complex geometry has to be engineered completely in 3D from first sketch up to CNC production
incl. geometry for blanks!

We guarantee digital production processes!

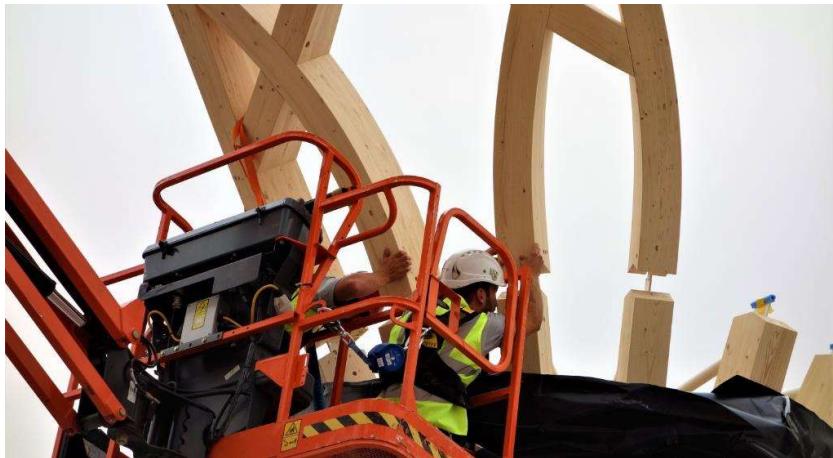


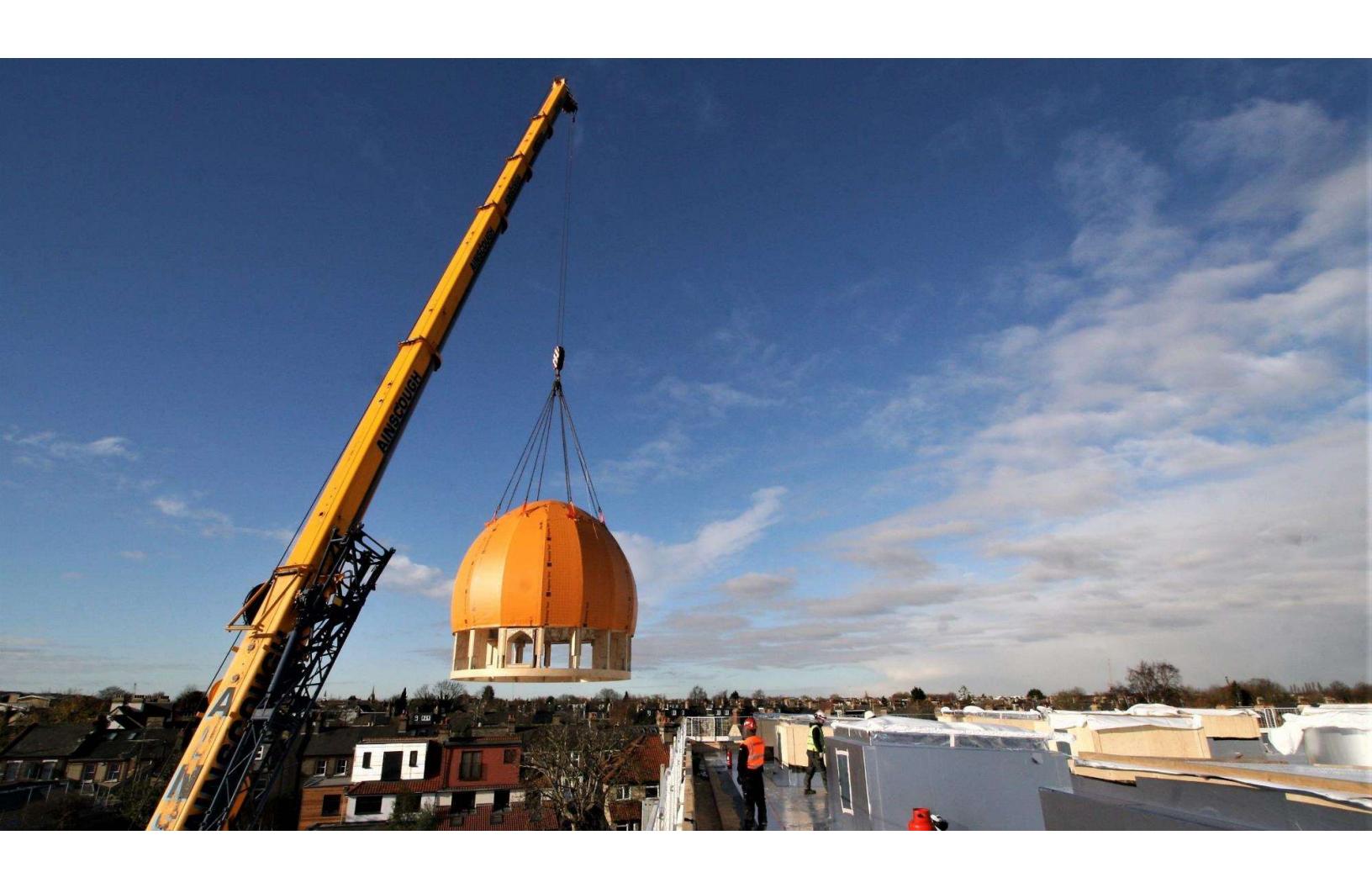
CNC Machinery



- Modern machinery
- Hundegger K3
- Hundegger SPM
- Weinmann
- Krüsi: Lignamatic
- Techno Wood C5500
3U8C

Video





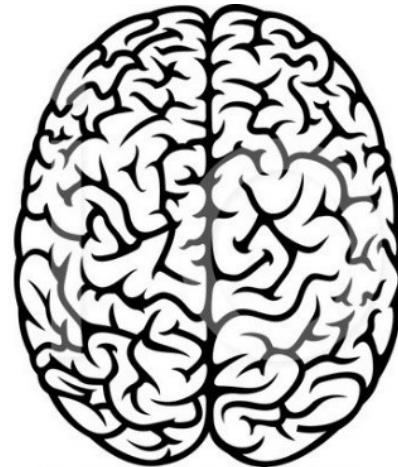


So you think you can freeform?

Into the Designer's psychology

10 Scenarios

No right or wrong answers



Scenario 1:

Your new boss asks you if you **want** (you don't have to) to get involved in a geometrically complex project in Hawai'i. It will require you to forget what you knew about design until now and learn completely new things.

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- «Can I get involved later, after I gain some experience in the company?»
- «Very interesting, but what do you mean by "geometrically complex project"?»
- «Easy yes, when are we going to Hawai'i?»
- «Let me think about it for a few days».
- «I would rather stick with «normal» projects».

Scenario 2:

The architectural concept of the project has been agreed without a final solution from the engineering perspective. You are asked to deliver a working geometrical solution on the pattern of joints between panels using new software.

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- «Can I go back to the “normal” projects?»
- «I need some formal training on that software first».
- «I better learn that software yesterday and work out the problem».
- «Can you please help me with the software and I will try to deliver as soon as possible».
- «Why did we not solve this concept at the bid stage?»

Scenario 3:

You have found a good way to split the surface into boards as per the project agreement, and the architect likes the joint pattern. However the wood prices have skyrocketed and your boss asks you to work with the supplier to match his supply board lengths (cheaper), with your design.

Scenario 3:

You have found a good way to split the surface into boards as per the project agreement, and the architect likes the joint pattern. However the wood prices have skyrocketed and your boss asks you to work with the supplier to match his supply board lengths (cheaper), with your design.

- You bring up the issue in the next project meeting and try to find solutions to compensate for the additional cost in other parts of the project.
- You don't know what to do, you just hope the lumber prices will drop.
- You create histograms on Excel connected to the parametric model and call the supplier to optimise the lumber demand and supply.
- It will be too complicated to change the board layout – the architect is happy and the project has to move on.

Scenario 4:

Wind is a major issue in external panelised structures. At the final stages of the structural design, the architect sends you a wind study document reminding you to quote loads from there. You have never seen this document before and it indicates loads almost twice as high as the ones you have designed for.

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- You grab your boss and decide whether following this wind document is necessary.
- You go back to your calculations and update the board and connection sizes to present to your boss.
- You tell the architect that you have finished the design following the appropriate codes and that this is sufficient.
- You tell the architect and project team that the impact of this wind study will require a redesign and more time. It is a great opportunity to buy some more time in the project.

Scenario 5:

The frustrated architect calls at 16:00 on a Thursday to complain that the amended shape of the ceiling is “too flat”, while you have just delivered the final geometry to your boss and were looking forward to an easy Friday.

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- You politely say that he will have to speak with your boss about it.
- You stay on the phone until late in the evening to explain why you have arrived at this final shape and maybe find a middle solution.
- You set up a follow up call for Monday to buy some time to discuss about it with your boss first.
- You freak out, find an excuse to end the call, and run to your boss for help.

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- A long night awaits you and your 3D model.
- Time for an express team meeting to discuss about solutions.
- You call the CNC guys and tell them you have to delay production by a few days, while you fix the clash.
- You are going ahead with production despite the clash and think of ways to modify the clashing panel in retrospect.

Scenario 7:

CNCd pieces come back to the factory and your crew realise that the names on the boards are printed incorrectly.

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- «That is a small issue, let's focus on the panel assembly because time is pressing».
- «It could be a drafting error, I will talk to my team».
- You call the CNC guys to understand the problem.
- You look for the error yourself in the parametric model and drawing production.

Scenario 8:

The crew in the factory complain that the assembly drawings are not clear enough and it causes mistakes and delays, and that they feel the pressure of being the bottleneck of the project.

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- You tell them to keep with the work sequence as changing the drawings will cause an even bigger delay and increase the risk of mistakes.
- You delegate the task of reviewing the drawings to the drafting team.
- You try to find drawing alternatives by looking at the parametric model data.
- It is time for your boss to intervene.

Scenario 9:

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- He should immediately get in touch with the mechanical engineers and site manager to check if the pipes are in the wrong places. You are on the phone to support with that.
- You stay on the phone until you go through each clashing location with him and find a solution.
- You say you will talk to your boss and look into the model while construction is moving on and come back to him – you can't afford mistakes from quick changes.
- The survey locations are correct – the pipes must move.

Scenario 10:

You get another phone call from the superintendent in the construction site, halfway through installation, who says that he is already running out of nuts and washers for the panel connections to the ceiling. It turns out the material counter in your parametric model had a mistake after the changes due to the increased wind load requirement.

Scenario 10:

You get another phone call from the superintendent in the construction site, halfway through installation, who says that he is already running out of nuts and washers for the panel connections to the ceiling. It turns out the material counter in your parametric model had a mistake after the changes due to the increased wind load requirement.

- He should locally source extra material to minimise delays on site.
- You discuss and estimate how many more days he can still work with the remaining material. The next container is on its way.
- You ask him to install panels with fewer nuts and washers, as per the original design, while the next container is coming.
- You apologise for the mistake, load the following containers with extra material and hope that it arrives before he runs out.

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- You are the master of your parametric model and others are unlikely to understand it.
- Seeking for help is a good idea, but creative initiative will almost always be a faster and better solution.
- Design only stops when the project has been built.



That's all folks!