Wood's Material Performance : Ray 2

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Ray 2 is wooden environment responsive screen system that reacts to changes in relative humidity. Based on the material properties of wood, cut in the tangential section, the system opens in dry weather thus airing the construction. Whilst in the humid conditions it closes, not allowing the moisture into the structure.

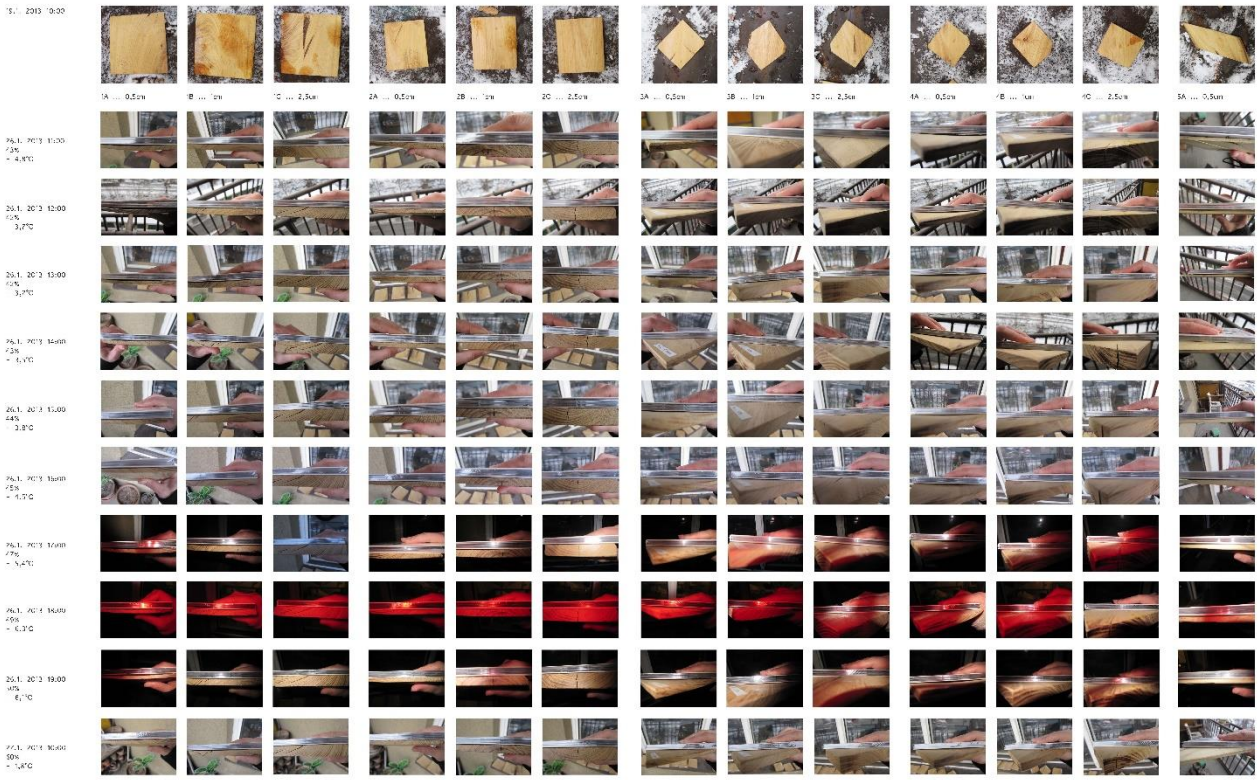
The research method is Systems Oriented Design that is mapping complex interdisciplinary data into so called GIGA-maps all the way through the design process.

Samples Observations:

The complex interdisciplinary study was coming hand–in-hand with the samples observations. Various shapes and thicknesses in the tangential section were registered for their material – humidity interaction. It was discovered that the samples from reaction wood reacts unexpectedly, while "normal"wood has quite clear behaviour after the internal stresses disappear. Hoadley explains reaction wood as follows:

“Reaction wood is a term applied to abnormal wood formed in tree stems and limbs that are other than erect, that is, parallel to the pull of gravity.” (Hoadley 1980)

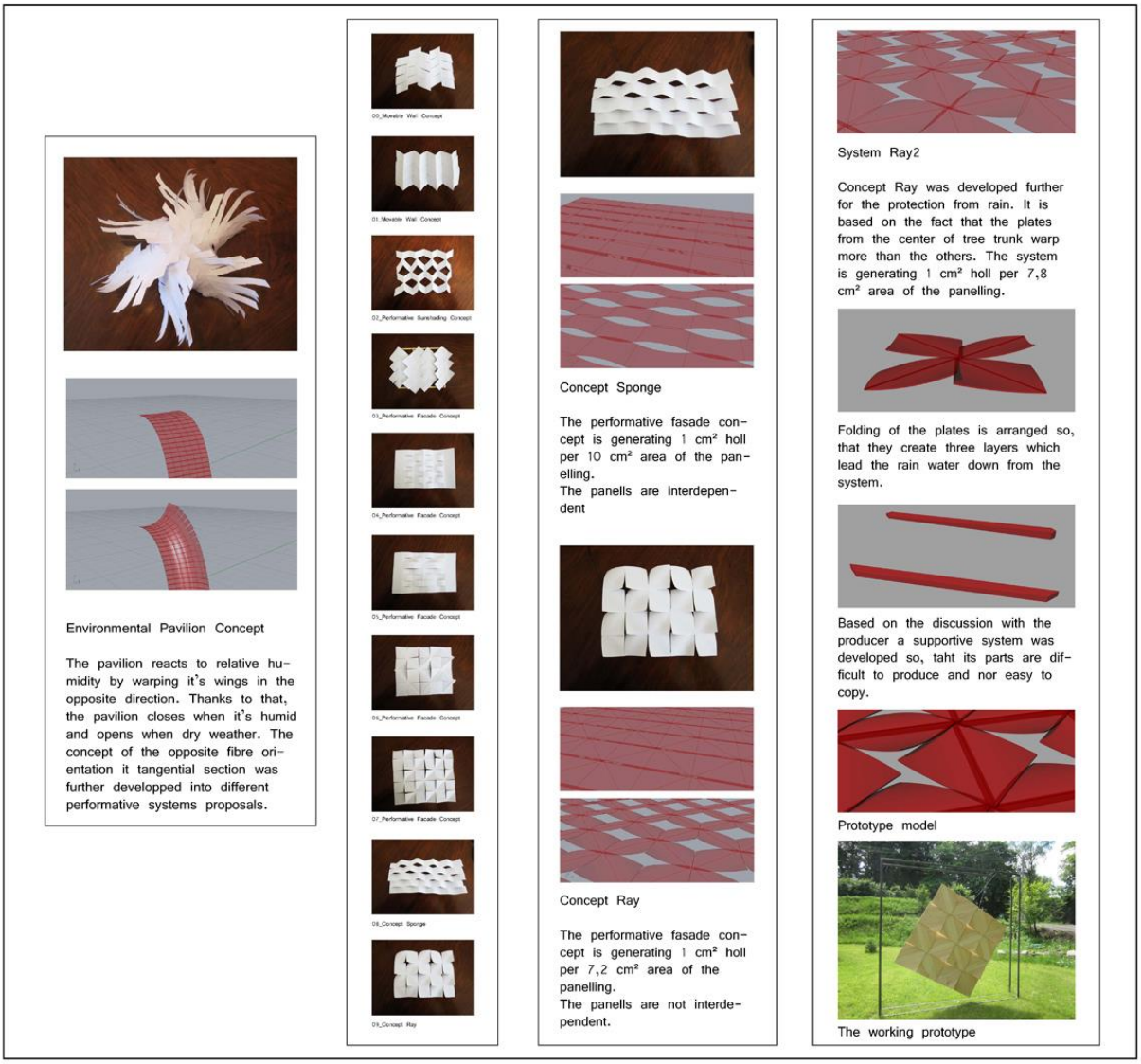
The samples from the reaction wood of false acacia were warping both directions (left and right side) in the same environmental conditions. The ratio of left and right side bending was 1:1 while in “normal” pine wood it was a 10% mistake which disappeared after some time. The mistake was caused by internal stresses that stay in the tree trunk even in normal wood (Zeidler 2013, personal conversation). During the measuring, it was found out that rhombus shape warps twice as much as square shape. This figure was replaced by two triangles due to the material waste latter on in the design process.



Samples with Different Thicknesses and Shapes of False Acacia (reaction wood) Measured from One Morning to an Other (Davidová 2012)

Warping of 0,5 cm Thick Normal Pine Samples in 10% RH and 21°C (Davidová 2013)

Design Process:

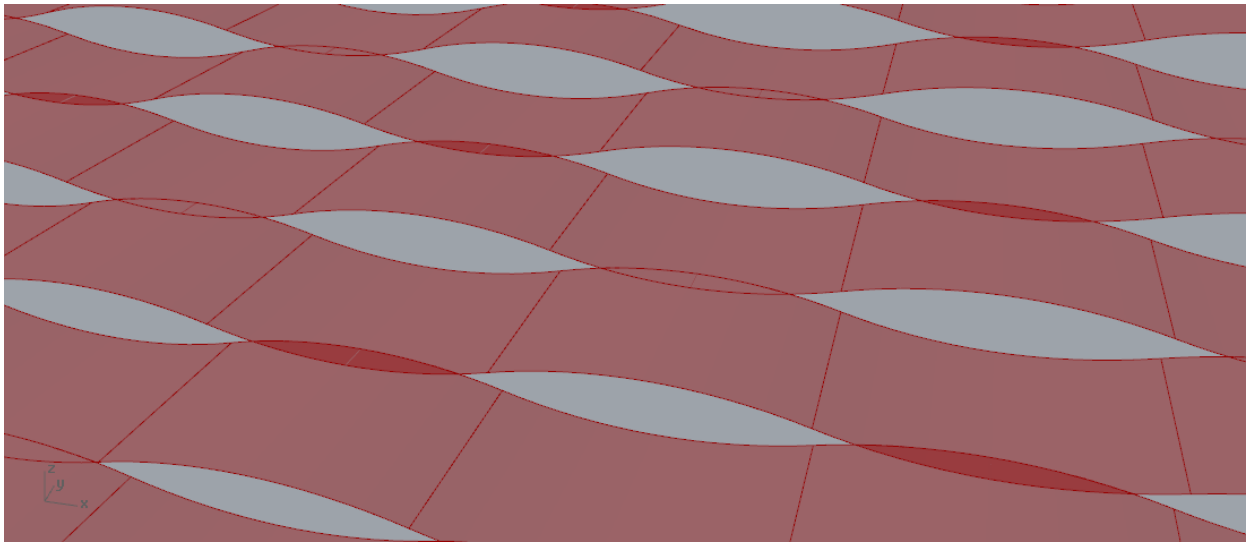


System Development (Davidová, 2013)

After the observations, several responsive systems have been sketched. The concepts covered a pavilion, facade systems and sun shadings. The two most reasonable of them were selected for evaluation for their performance in parametric models in Grasshopper for Rhino 5. The data from the registering of the samples were implemented in the definition.

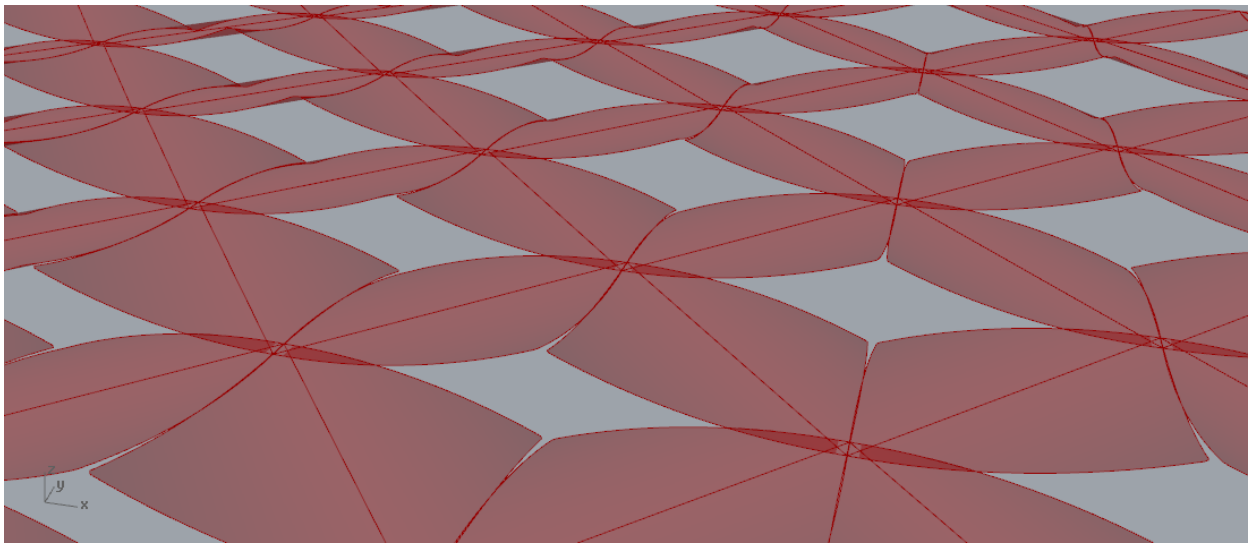
Both concepts, Sponge and Ray, are façade systems that react to humidity by airing the structure during dry weather while closing up in humid weather.

System Sponge is well resistant to sudden rain, when the structure wouldn't be closed yet. It was found out from the model simulation that the structure would generate 1 cm² airing gap per 10 cm² of the surface in 10%RH and 21°C. The disadvantage is that the system is interdependent which is quite risky with uneven material such as wood. Furthermore, the whole structure would shrink.



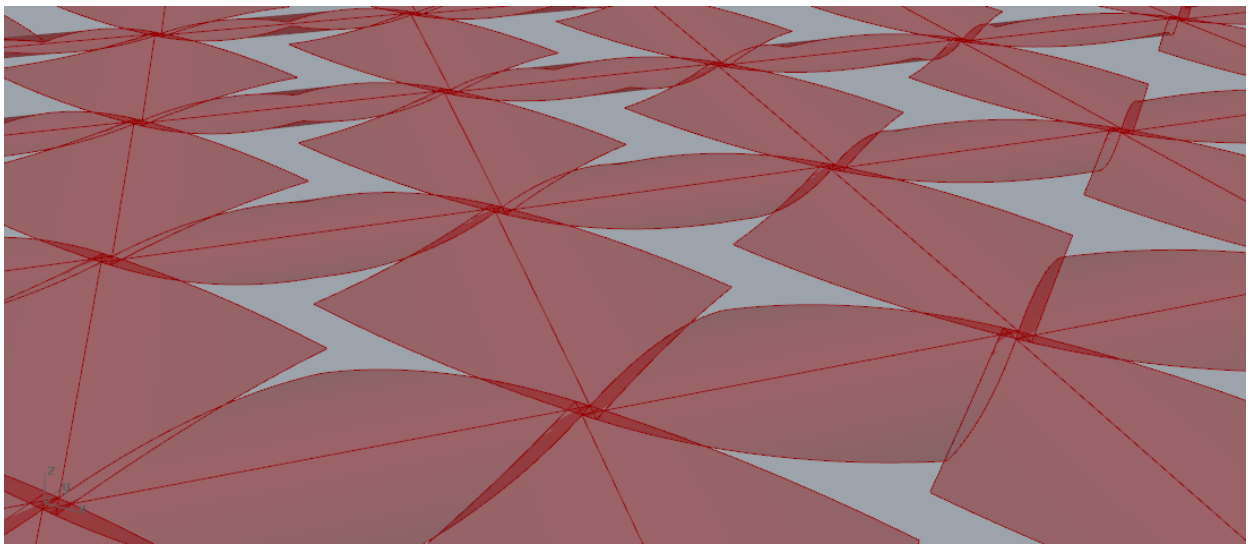
Concept „Sponge" - parametric model (Davidová 2013)

Concept Ray is not resistant to sudden rain but the parts are independent. Its performance is much better. The simulation shows that in 10%RH and 21°C, it generates 1 cm² airing gap per 7.2 cm² of the surface area because of the use of the triangles that warp more than the rectangles.



Concept „Ray“ - Parametric Model (Davidová, 2013)

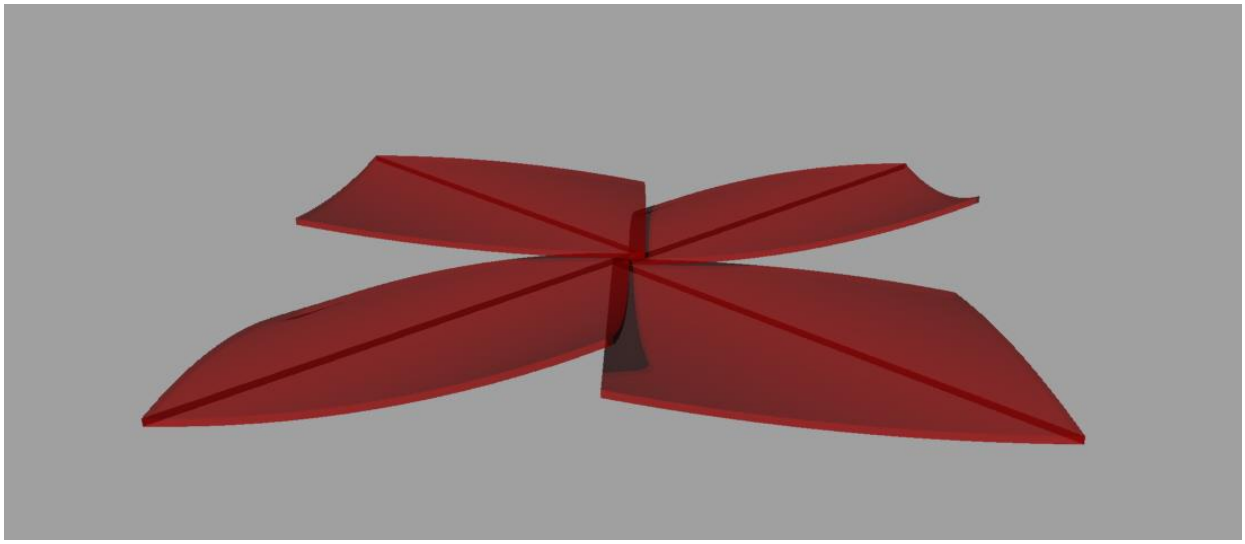
Going back to the GIGA – map covering the common knowledge on wood material science, the system Ray was further developed into Ray 2 which is resistant to sudden rain. Hoadley demonstrates that the tangential cuts from the centre of the tree trunk warp more than the cuts on the border of it (Hoadley 1980) which enables the overlapping of the triangular plates.



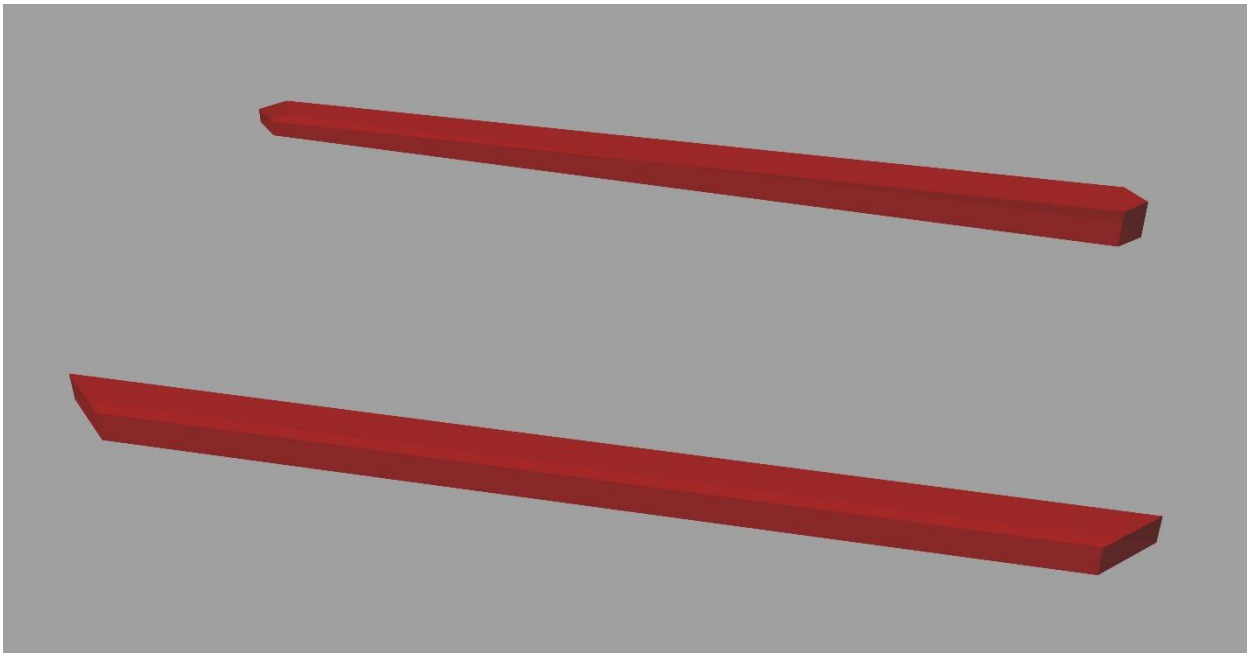
Concept „Ray2“ - Parametric Model (Davidová, 2013)

Such a structure generates 1 cm² airing gap per 7.8 cm² of the surface area in 10%RH and 21°C which is good enough for the performance.

The plates are layered as such: There is one upper plate from the border of the trunk in the left – right diagonal, the right – left diagonal is in the same layer and is from the centre of the trunk and the lower plate from the border of the tree trunk in the left – right diagonal comes underneath.

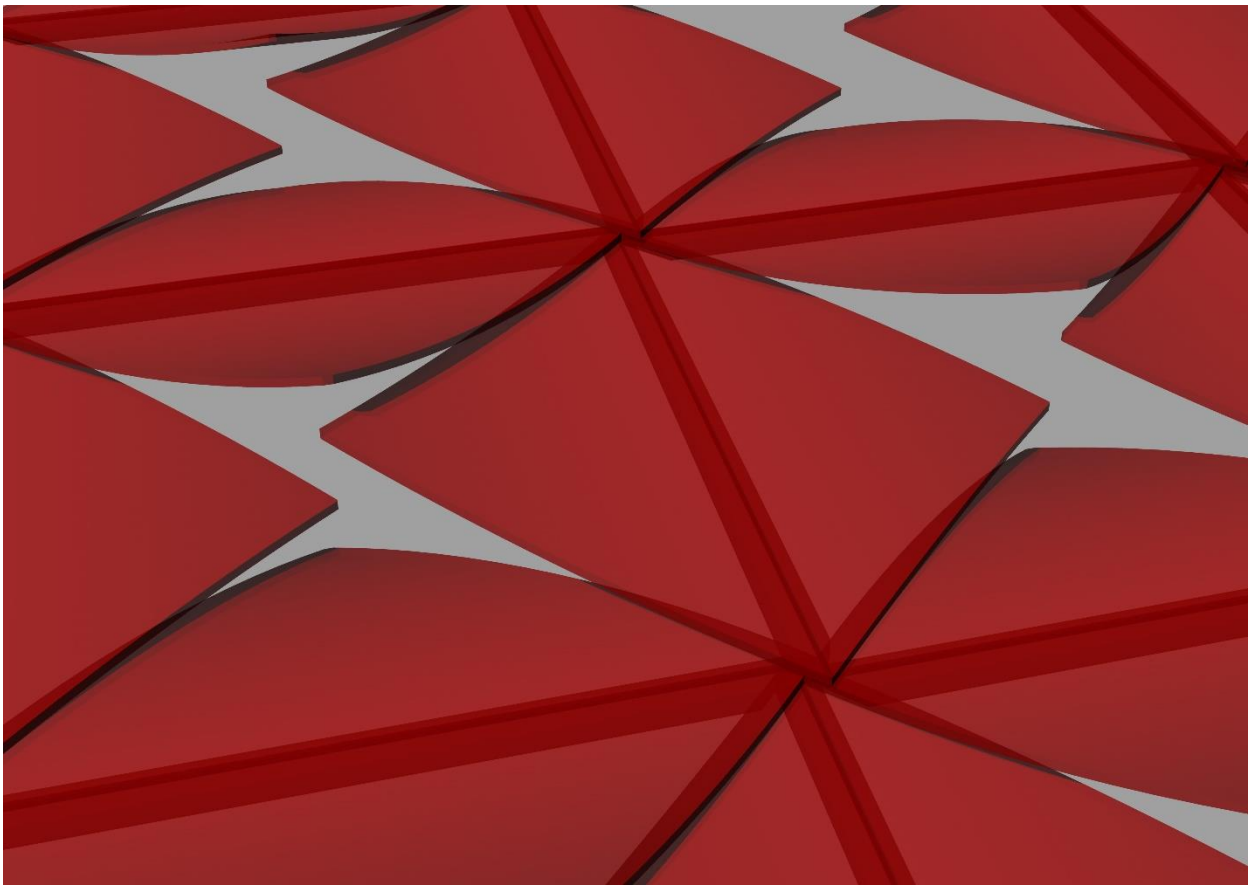


System „Ray2“ - Layering (Davidová, 2013)



System „Ray2“ - Base of the Plates (Davidová, 2013)

After the discussion with carpenters, the basis under the plates were designed at a certain angle for the protection from copying.

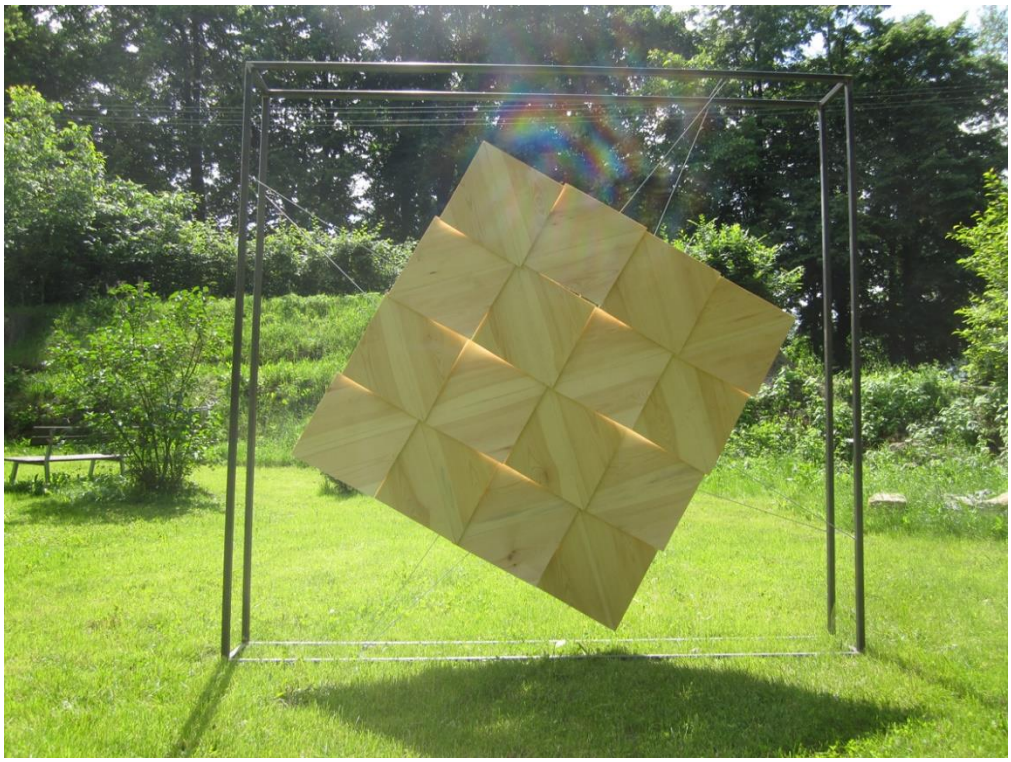


System „Ray2“ - Model of the Prototype (Davidová, 2013)

It was agreed that the product will be offered as a façade and roofing system. Ray 2 was prototyped in 1:1 scale and measured for its performance. Michael Hensel is explaining the need of full-scale prototyping for the material performance as such:

“…And so the question arises as to the context in which the necessary depth and breadth of inquiry and empirical knowledge production could take place. … One way forward is sustained research by design that can bridge between the basic research undertakings and testing by way of full-scale experiments within the target context.” (Hensel 2013)

It was measured that the prototype fully closes only when very high humidity is reached, which differs from the simulation.



System „Ray2“ - Prototype (Davidová, 2013)

System „Ray2“ - Prototype Detail (Davidová, 2013)

Conclusion:

The data-driven design played the crucial role in decision-making and development. The prototype behaved in the same way as the simulation except that it was made from wood that was too moist, so the closure appears only with an overly high level of relative humidity. This combination of parametric modelling and physical prototyping moves the design process forward. Wood cut in different moisture contents are observed on the samples and leads to a new prototype that will behave the same as the initial simulation.

Implementing the data measured from the samples to the parametric model can produce a trustworthy simulation. But it is necessary to consider a more complex background such as moisture content of the cut material.

The GIGA-mapping tool of Systems Oriented Design method can lead the decision-making all the way through the product development, from the start point to the end solutions.

Literature:

Hensel, M. (2013). "Performance-Oriented Architecture: Rethinking Architectural Design and the Built Environment". John Wiley & Sons. Winchester

Hoadley, R.B. (1980). "Understanding Wood: A craftsman's guide to wood technology". The Tauton Press, Inc. New Town.