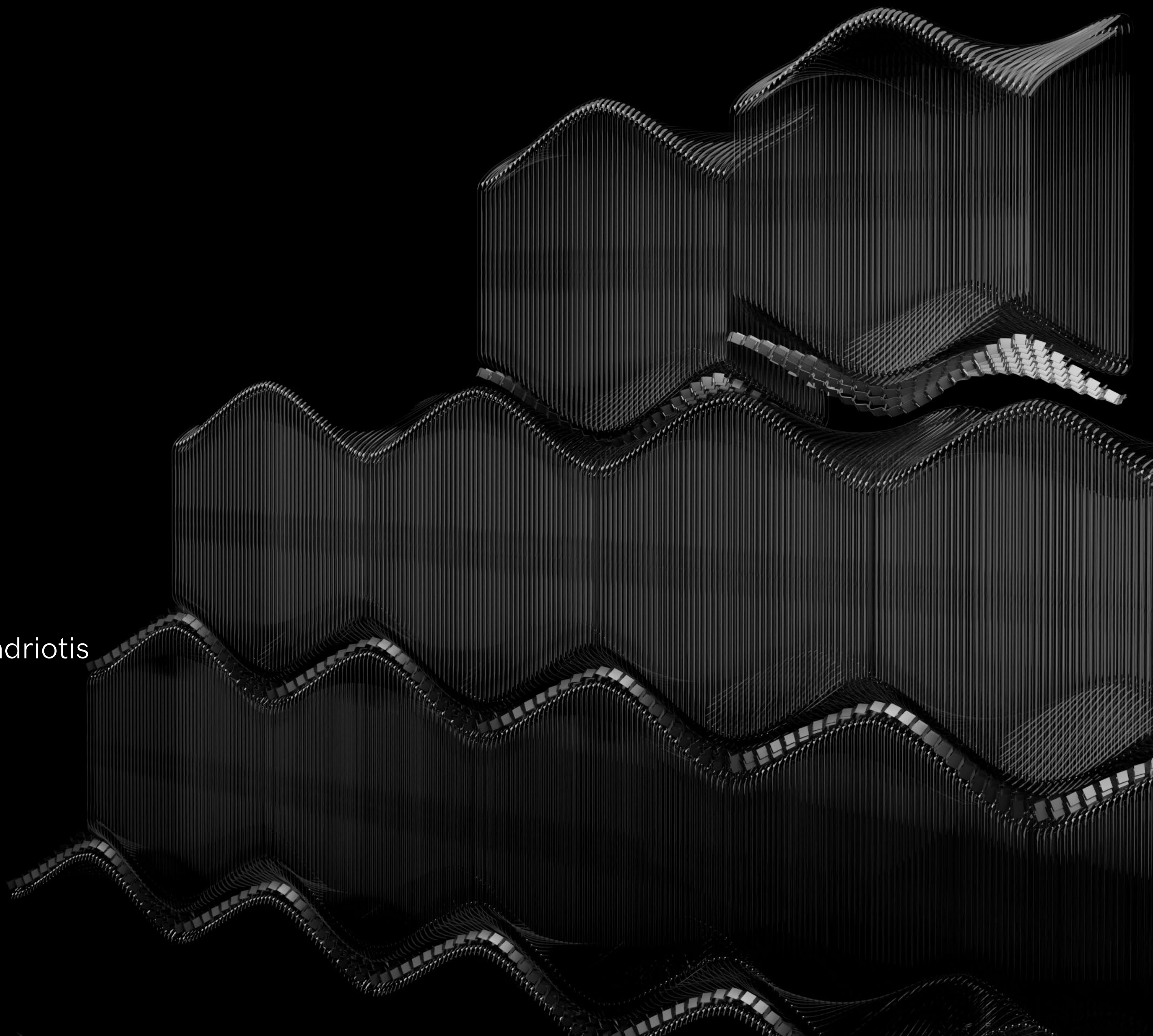
3D-Printed Glass Assemblies

A novel Workflow for **Circular Assembly** using **3D-printed Glass Masonry** Units with a **Kirigami-inspired interlayer**

Mentors: Dr. Faidra Oikonomopoulou | Dr. Charalampos Andriotis

MSc. Building Technology Graduation | P5 23 June 2025

Swornava Guha **5961815**



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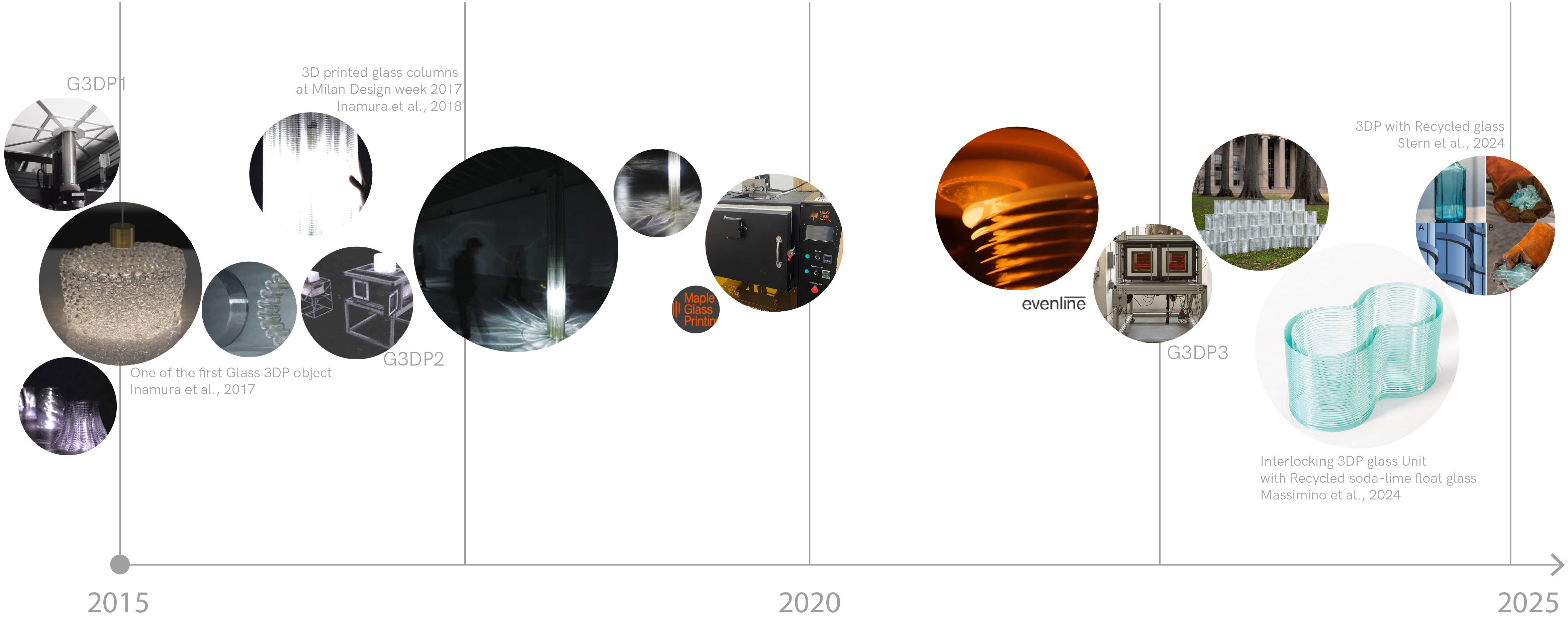
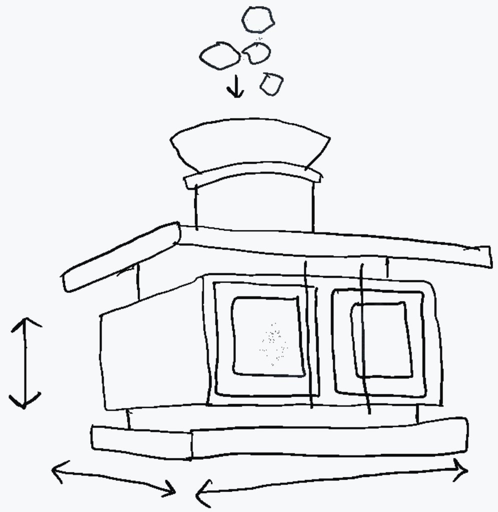
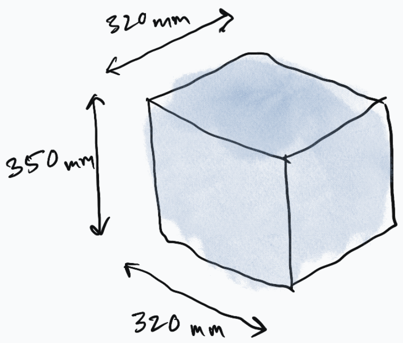
Reference images which might have copyright have been removed

"What if glass could be printed like plastic, assembled like LEGO, and disassembled – over and again?"


G3DP1
3D printed glass columns
at Milan Design week 2017
Inamura et al., 2018
One of the first Glass 3DP object
Inamura et al., 2017
G3DP2
Maple
Glass
Printin
evenline
G3DP3
3DP with Recycled glass
Stern et al., 2024
A
B
Interlocking 3DP glass Unit
with Recycled soda-lime float glass
Massimino et al., 2024
2015
2020
2025

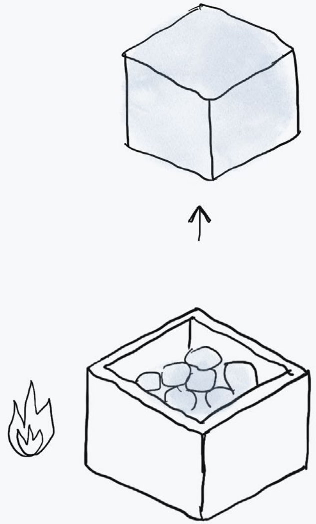
3D printing

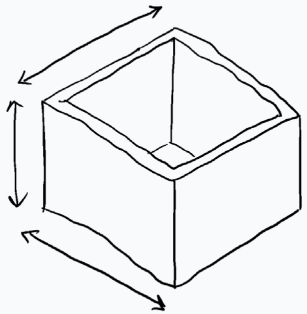




Massimino et al., 2024

Casting





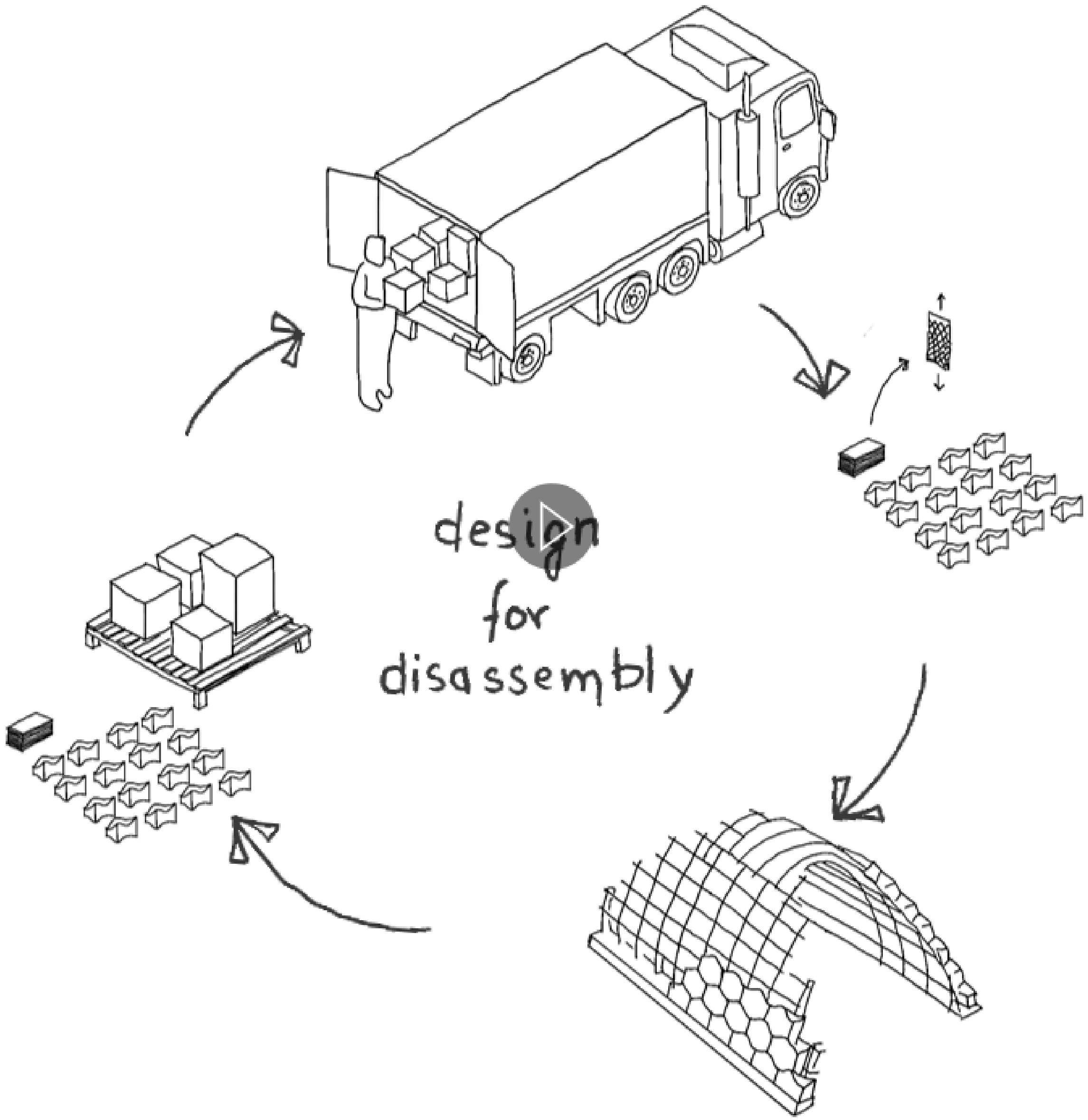
-Oikonomopoulou et al., 2018

Crystal House Amsterdam, MVRDV

Qammat Pavillion Greenland, Konstantin Arkitekter

Optical Glass House / Hiroshi Nakamura & NAP

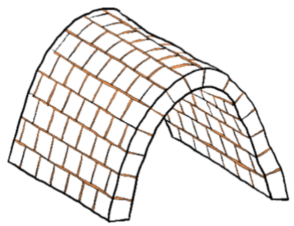
Glass Masonry in the Construction Industry- Examples

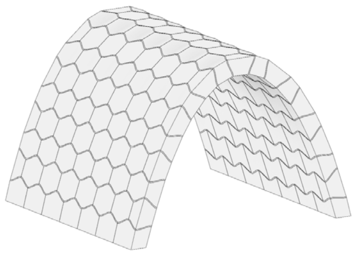


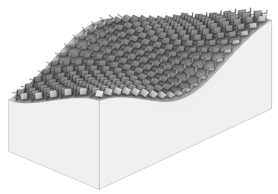
Design goals

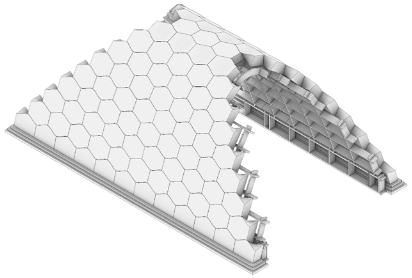
Develop **a methodology for designing reversible assemblies using 3D printed glass units**, along with a strategy to engineer the interlayer for a performance target

Objective

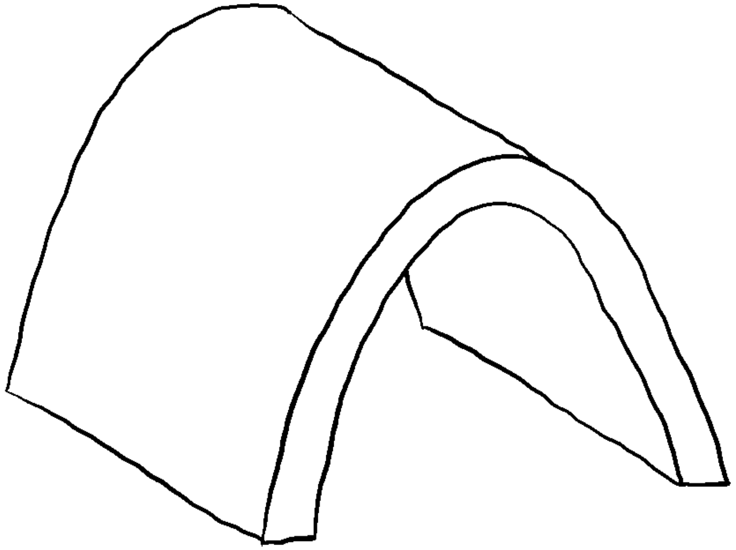






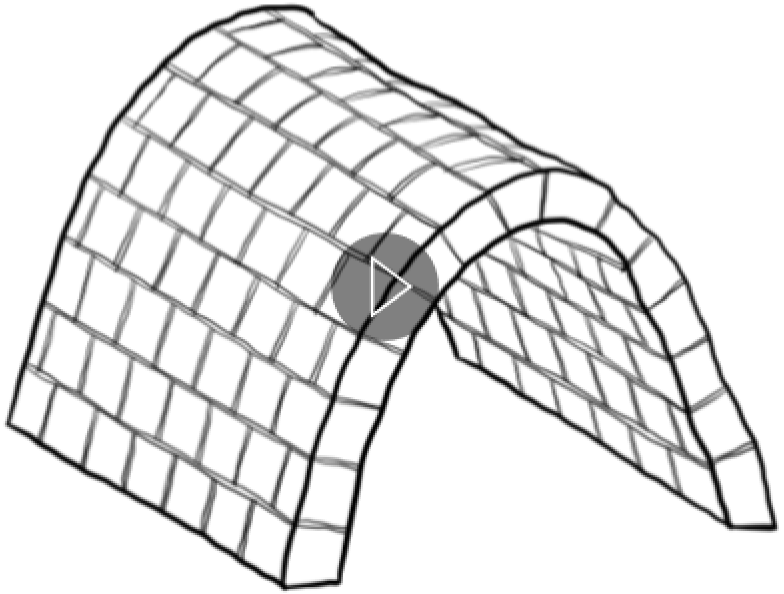


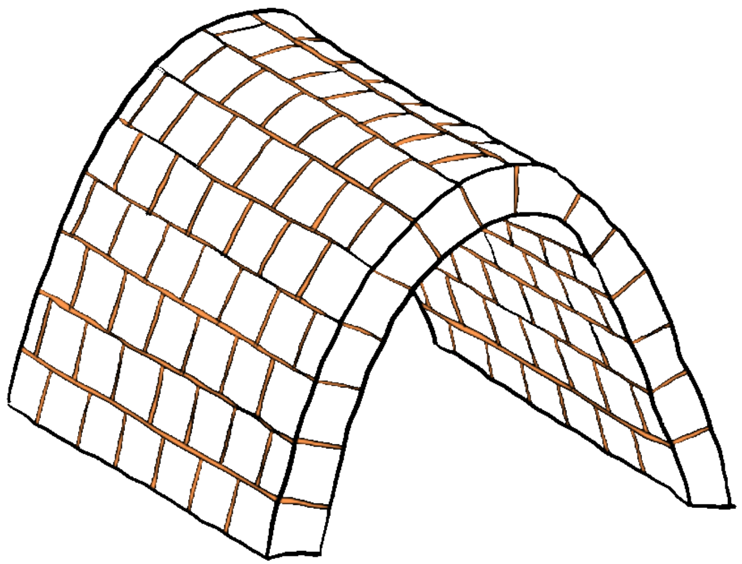
Contents

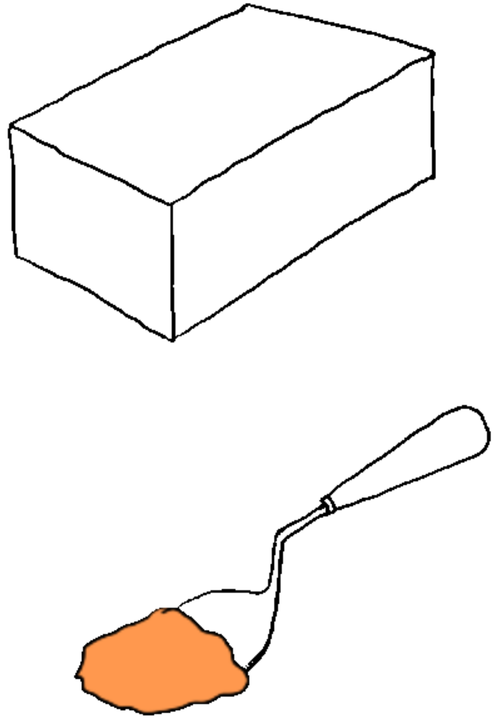


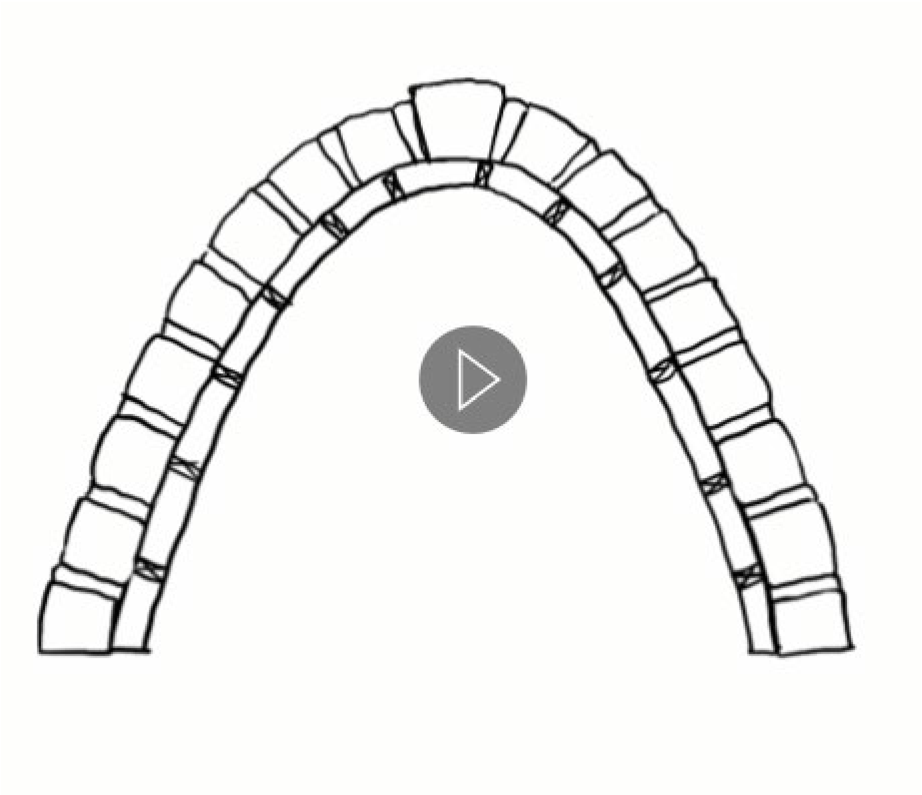
Ancient Jericho, 8000BC

Image source









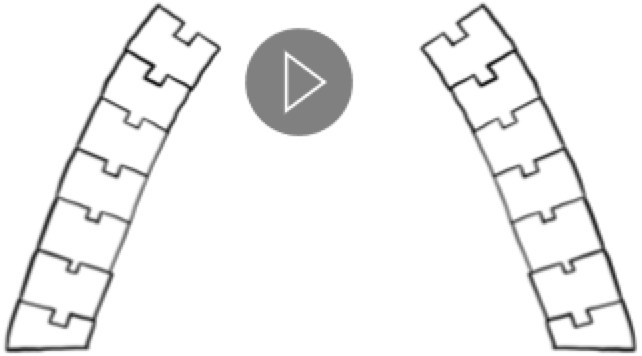
Bonded masonry

Interlayer

- ✓ Fabrication tolerances of masonry units
- ✓ Construction tolerances
- ✓ Creep

Permanent Structures
Reduced Recyclability of materials

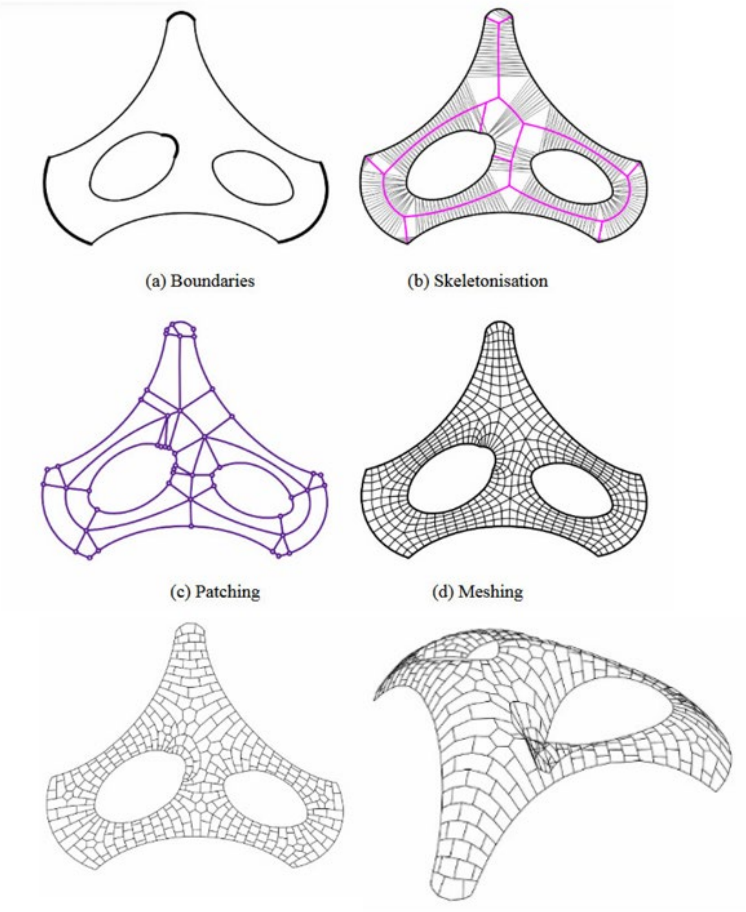

LEGO
education




Arch-Lock construction

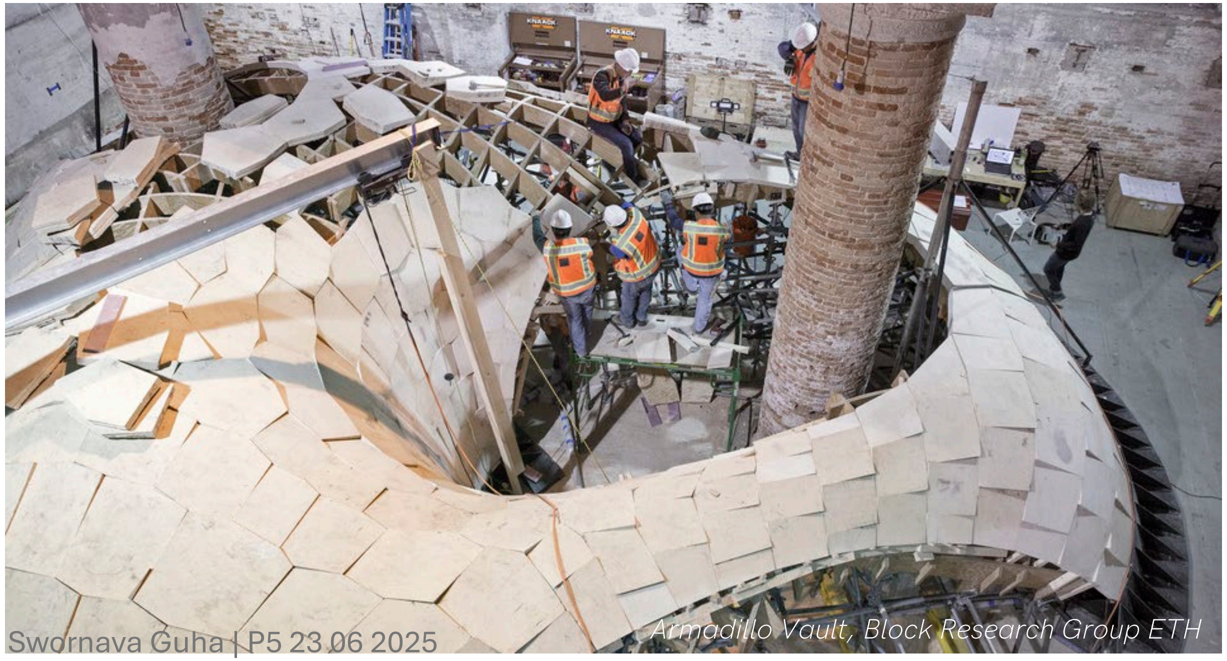

StoneFlow


Striatus- Zaha Hadid



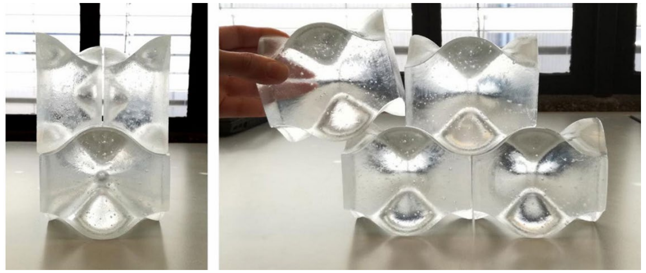
Tessellating dry masonry systems

Oval et al., 2017



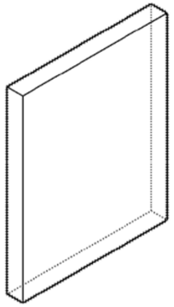
Armadillo Vault, Block Research Group ETH

Tessellating Glass Dry assemblies

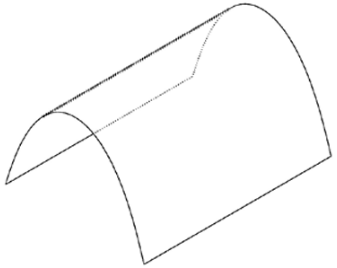


-Oikonomopoulou et al., 2018

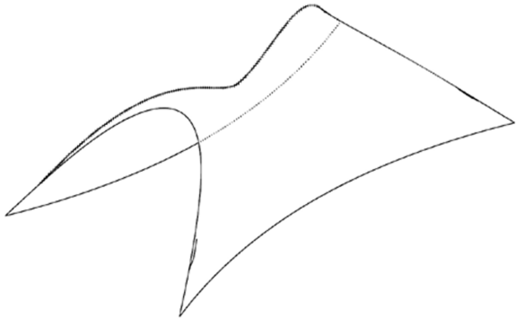
Wall



Catenary Vault

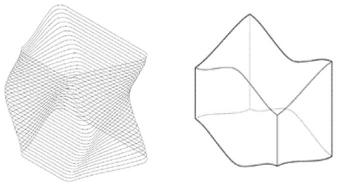


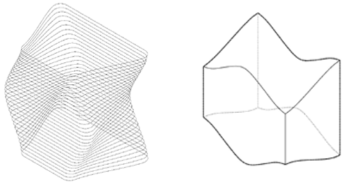
Compression-only shell

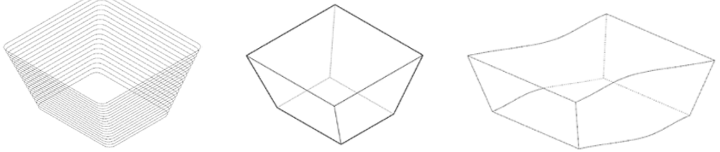


Block geometry

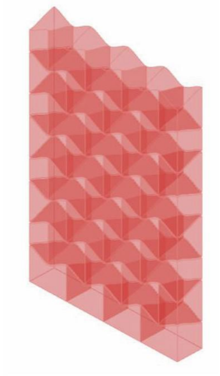
(3DP glass constraints)

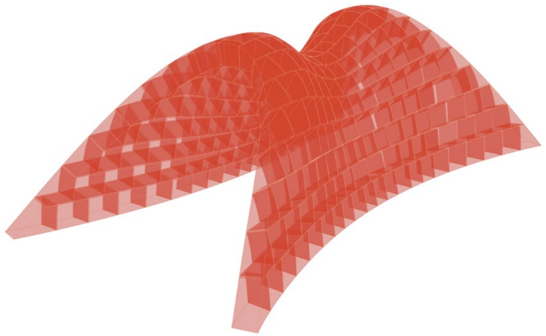


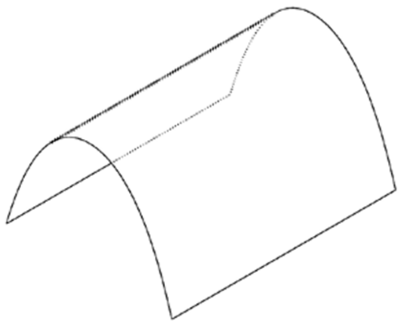




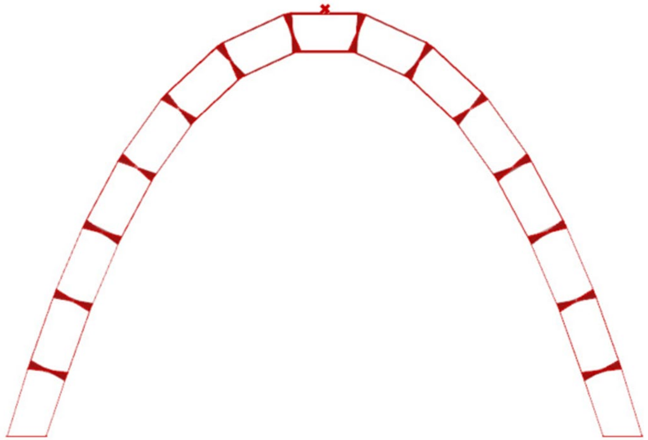
Tessellation



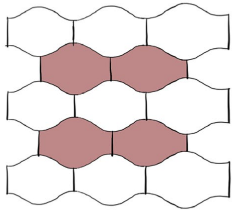


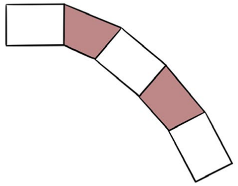


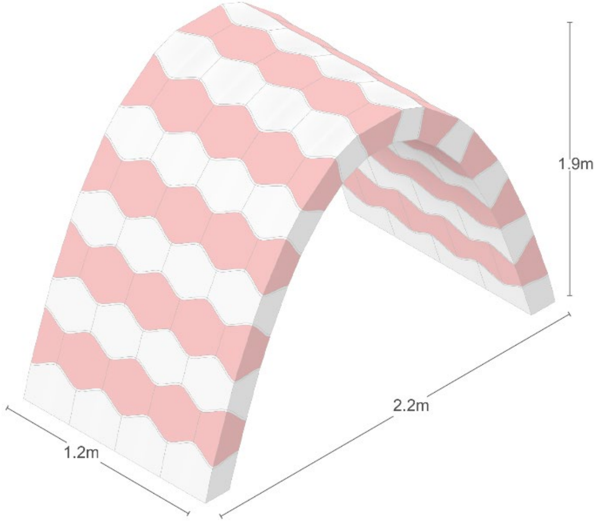
Span- 2.2m Height- 1.9m



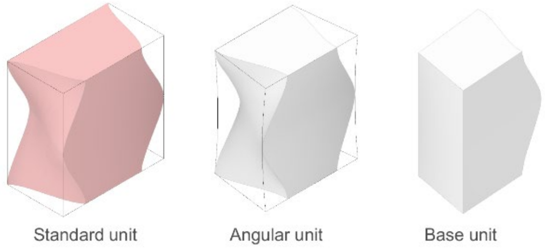
Unique angular blocks on each row

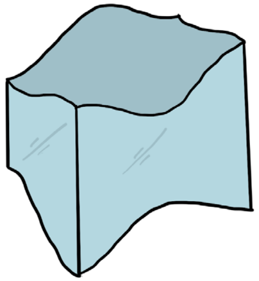




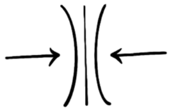


~50% standard units

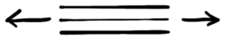




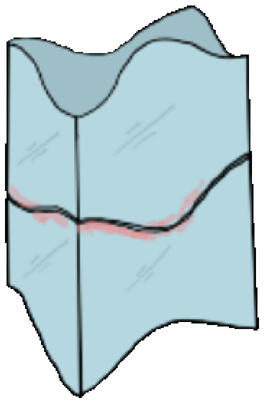
Glass



Compressive strength:
420 – 1000 MPa



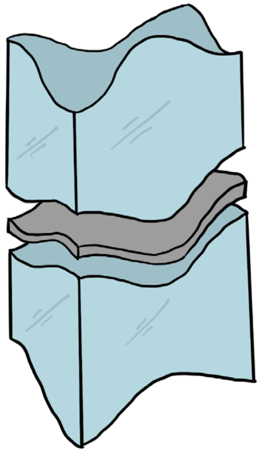
Tensile strength
35-45 MPa



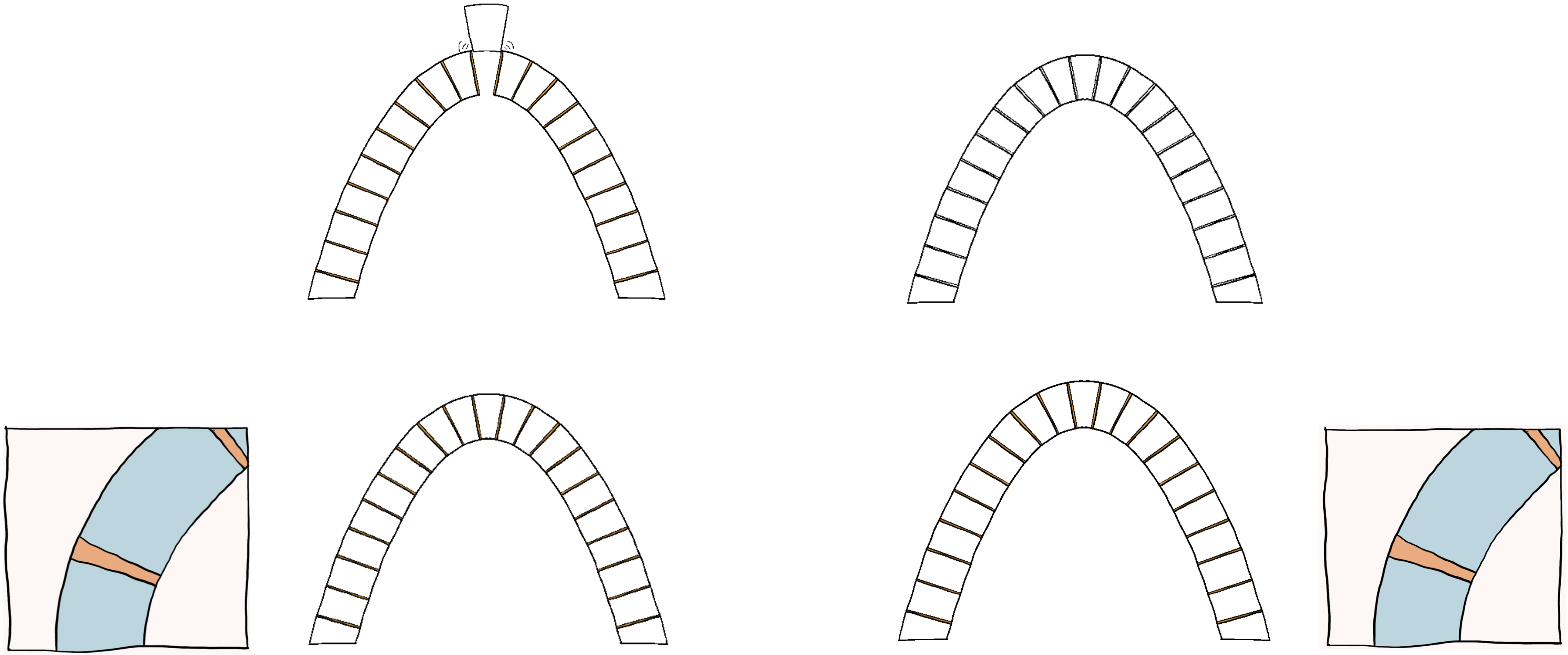
Glass-to-Glass

Brittle

Susceptible to defects



Glass-interlayer-Glass

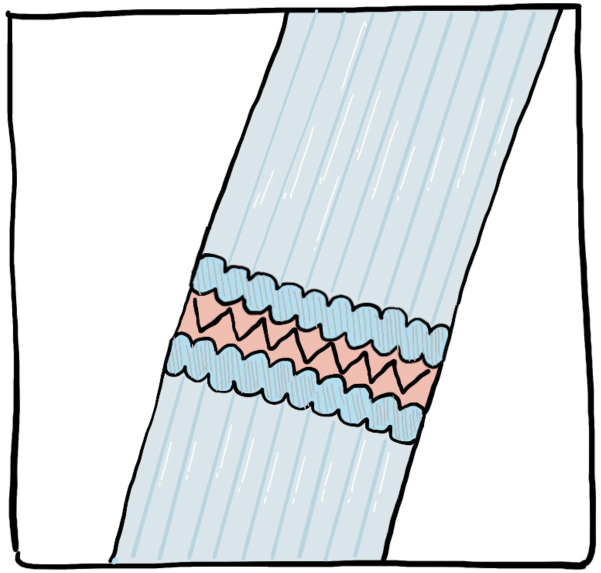


Very Stiff Interlayer

- ✓ Creep
- ✓ Minimum total deformation
- o No construction tolerances – unbuildable
- o Local peak stresses might occur

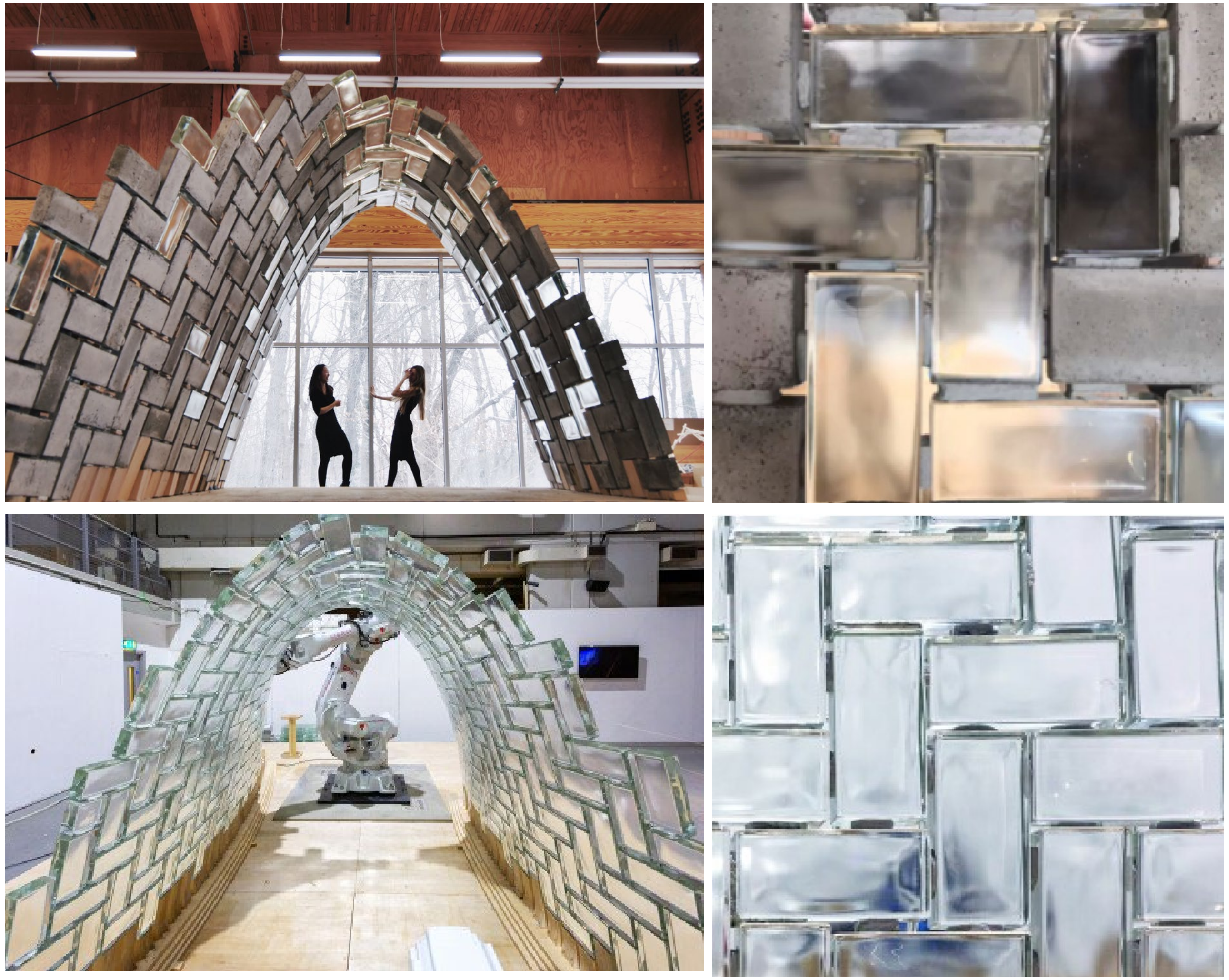
Very Soft Interlayer

- ✓ Surface tolerances
- ✓ Construction tolerances
- o Creep
- o Failure due to stress in glass



Required Interlayer

- ✓ Construction tolerances
- ✓ Surface levelling
- ✓ Resist vertical and lateral loads
- ✓ Creep
- ✓ **Manufacturable and Scalable**
- ✓ Flexible- into interlocking geometry
- ✓ DRY assembly



Glass Vault, Princeton University

WHAT INTERLAYER TO USE?

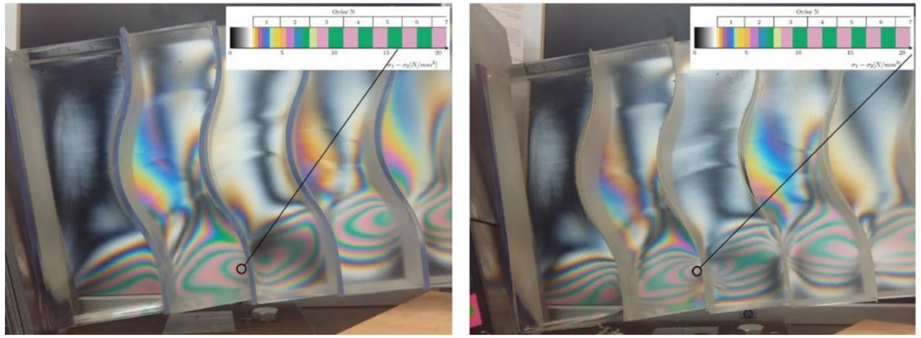
Selection of interlayer

Design

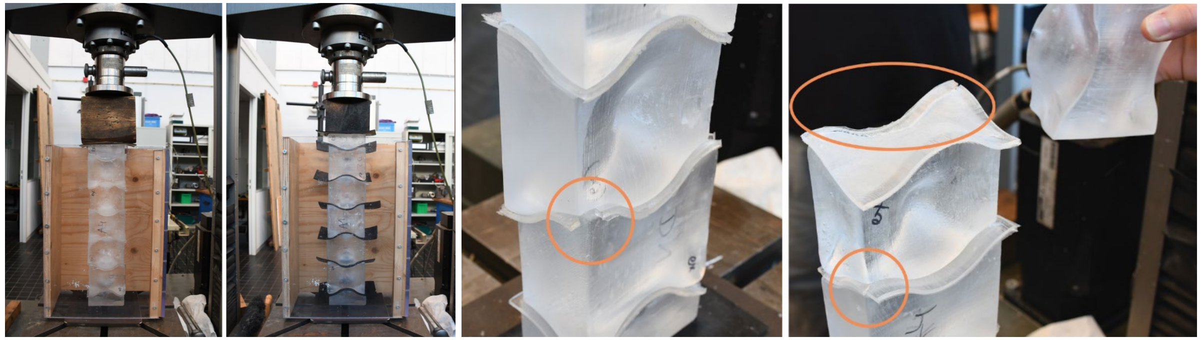
Select interlayer material(s)
from a vast material space

Experimental testing of its performance based on application

50MPa to 5000MPa



-Aurik et al., 2018



-Oikonomopoulou et al., 2018

Design
with arbitrary interlayer

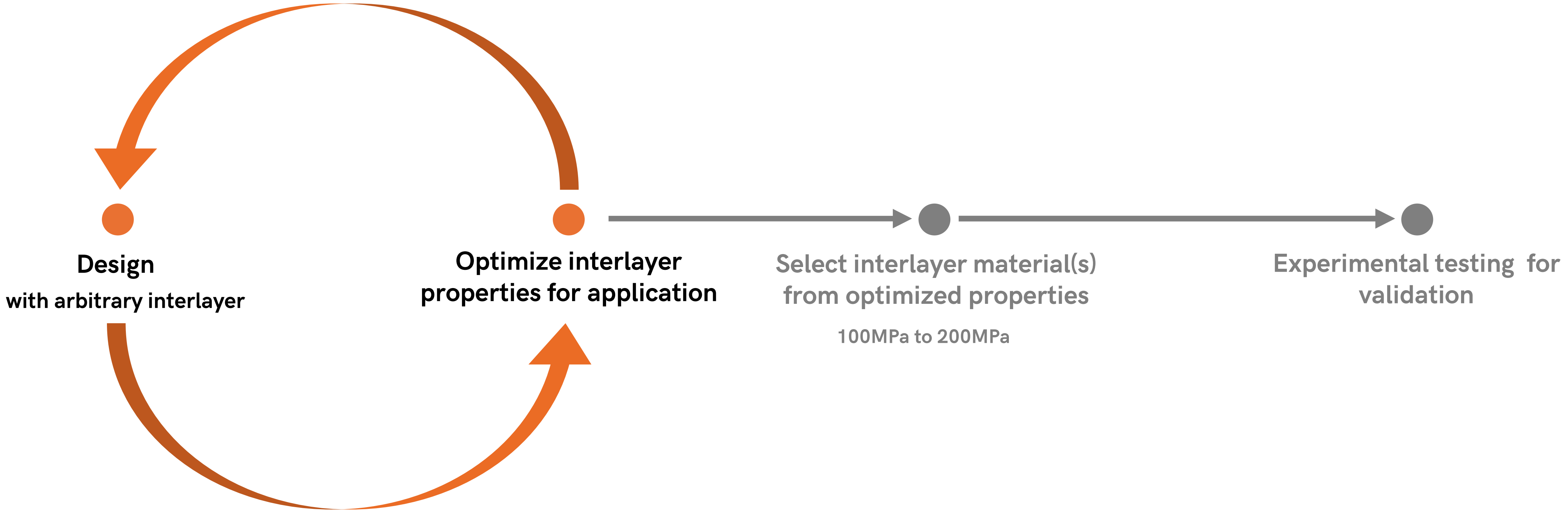
Optimize interlayer properties for application

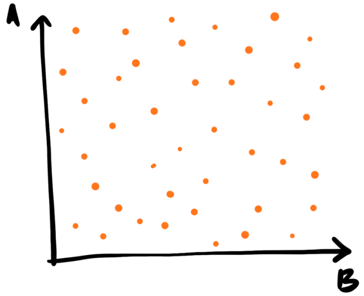
Select interlayer material(s) from optimized properties
100MPa to 200MPa

Experimental testing for validation

Engineering a kirigami-inspired aluminum interlayer for target properties

Proposed Method

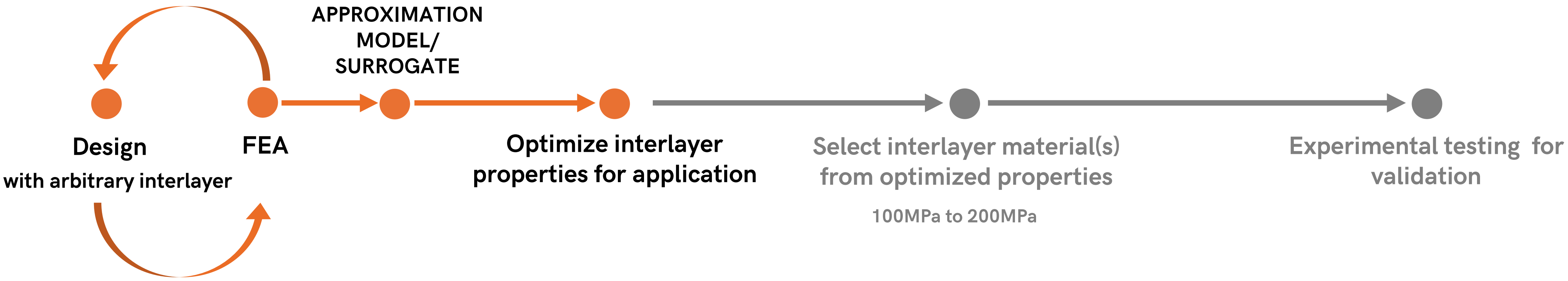


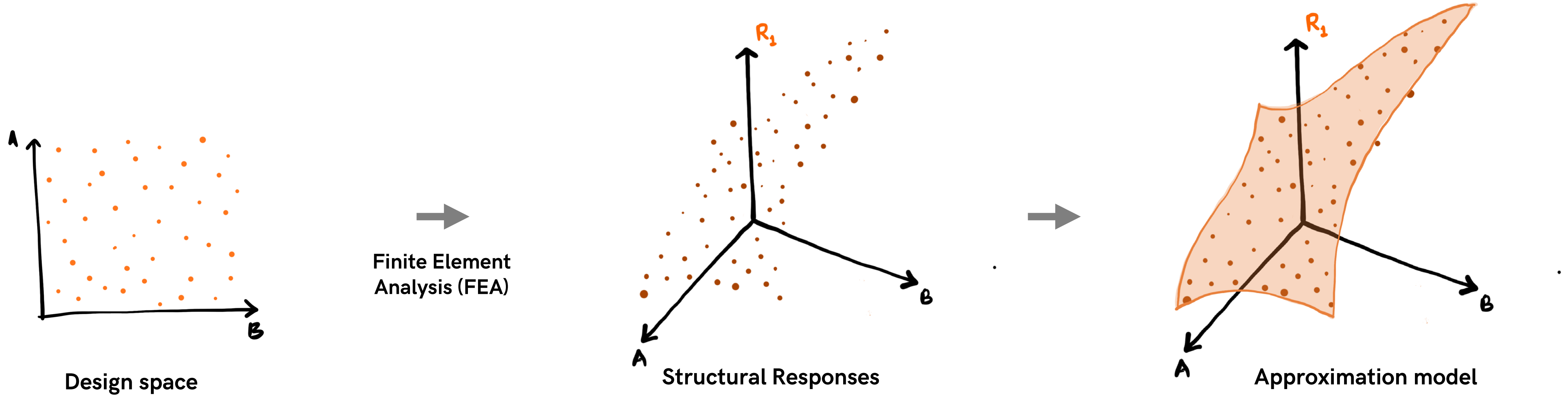


Design space

Proposed Method

Proposed Method





Design
with arbitrary interlayer

FEA

APPROXIMATION MODEL/ SURROGATE

Optimize interlayer properties for application

Select interlayer material(s) from optimized properties

100MPa to 200MPa

Experimental testing for validation

GEOMETRY PARAMETERS

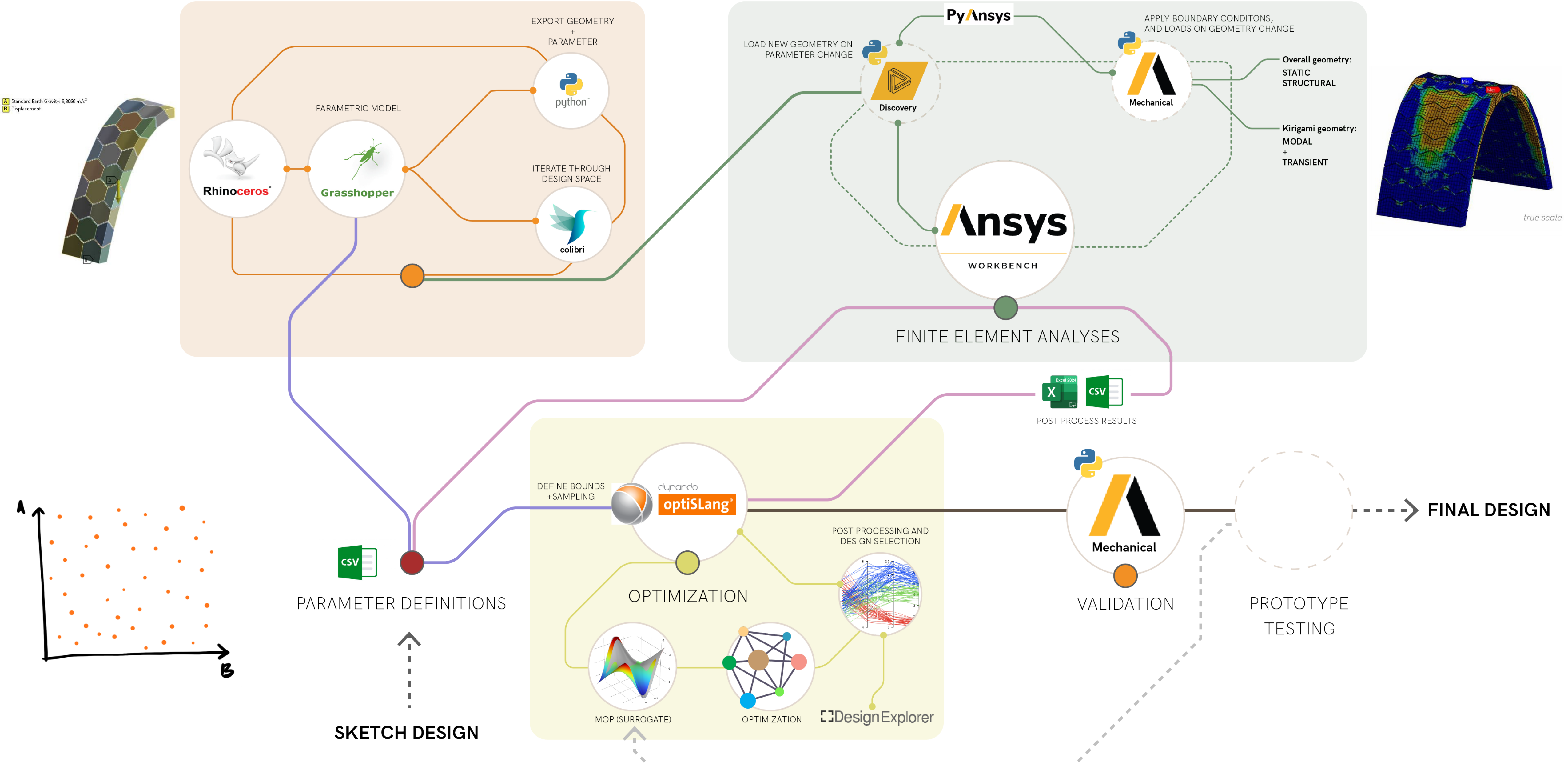
Rhinoceros® + Grasshopper + Plug-ins food4Rhino

FINITE ELEMENT ANALYSIS (FEA)

Ansys

Proposed Method

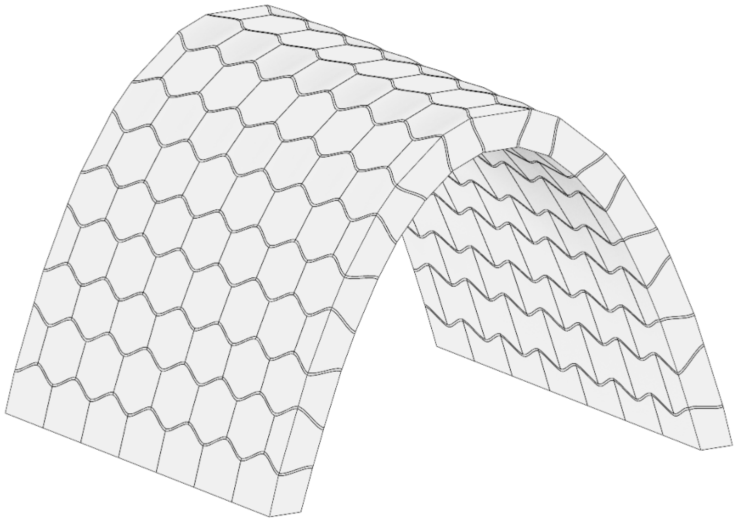
Workflow



Standard Earth Gravity: 9,8066 m/s²
Displacement
PARAMETRIC MODEL
Rhinoceros
Grasshopper
EXPORT GEOMETRY + PARAMETER
python
ITERATE THROUGH DESIGN SPACE
colibri
Py Ansys
LOAD NEW GEOMETRY ON PARAMETER CHANGE
Discovery
APPLY BOUNDARY CONDITONS, AND LOADS ON GEOMETRY CHANGE
Mechanical
Overall geometry:
STATIC STRUCTURAL
Kirigami geometry:
MODAL
+
TRANSIENT
Ansys
WORKBENCH
FINITE ELEMENT ANALYSES
true scale
CSV
POST PROCESS RESULTS
DEFINE BOUNDS +SAMPLING
dynardo
optiSLang
OPTIMIZATION
POST PROCESSING AND DESIGN SELECTION
MOP (SURROGATE)
OPTIMIZATION
DesignExplorer
TUNING MOP
A
B
CSV
PARAMETER DEFINITIONS
SKETCH DESIGN
Mechanical
VALIDATION
PROTOTYPE TESTING
FINAL DESIGN

CREATING THE DESIGN SPACE

GEOMETRY



PARAMETERS

Length of Masonry unit

Height of Masonry unit

Width of Masonry unit (thickness of vault/arch)

Amplitude of Masonry unit

Wall Thickness of 3DP

Thickness of the interlayer (t)

Area of the interlayer (A)

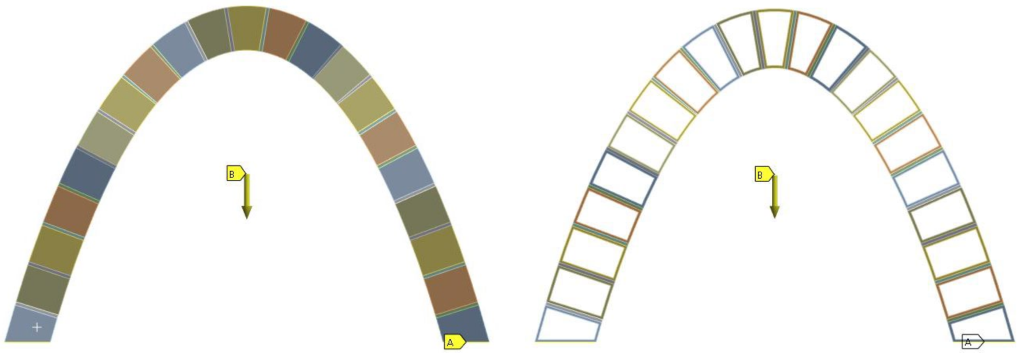
Material property of the interlayer (E)

Stiffness of interlayer

$$k = \frac{EA}{t}$$

k = Stiffness of Interlayer (N/mm)
E = Young's modulus of Interlayer (MPa)
A = Area of the interlayer (mm^2)(at one course)
t = Thickness of the Interlayer (mm)

GEOMETRY



FEA ON 100 DESIGNS FOR PARAMETER SENSITIVITY STUDY

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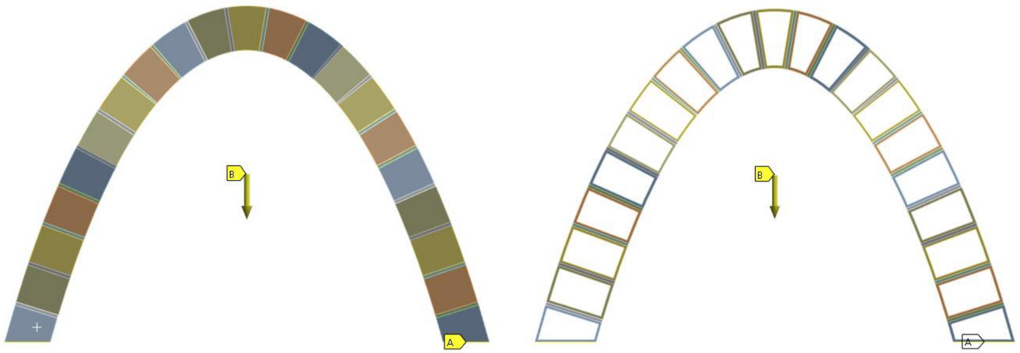
GEOMETRY



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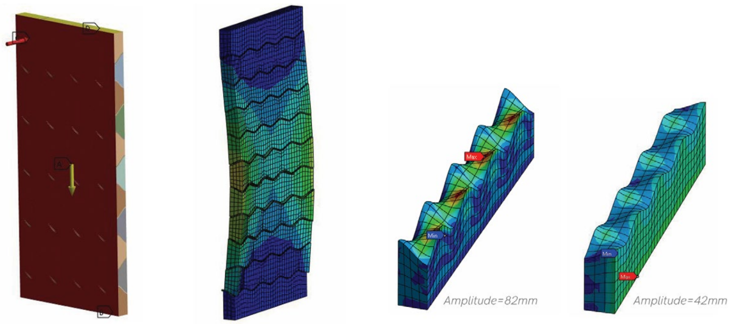
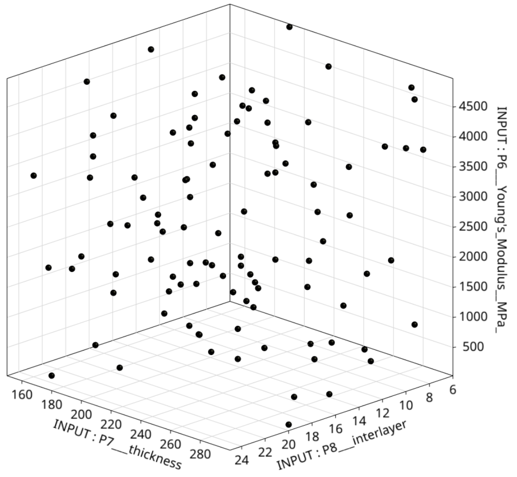


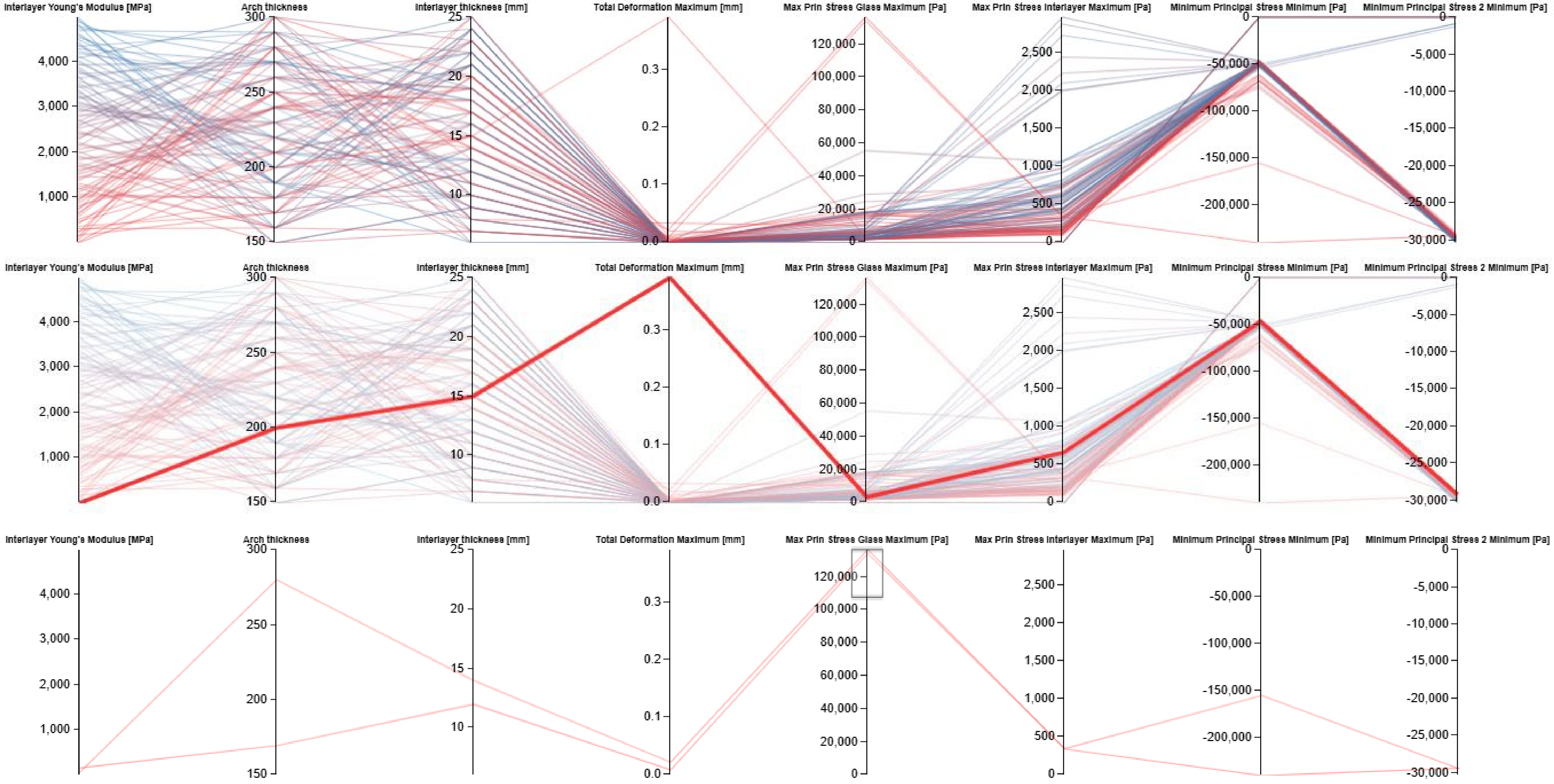
FEA ON 100 DESIGNS FOR PARAMETER SENSITIVITY STUDY

THE DESIGN SPACE:



GEOMETRY	INPUT			Design samples	OUTPUT
	Variables/ Constants	Bounds		Design samples	Response
2D Arch	Arch thickness (T) in mm	150	250	100	Max Tensile Stess in glass
	Interlayer thickness (I) in mm	6	25		
	Interlayer Young's Modulus (E) in Mpa	20	5000		Total deformation

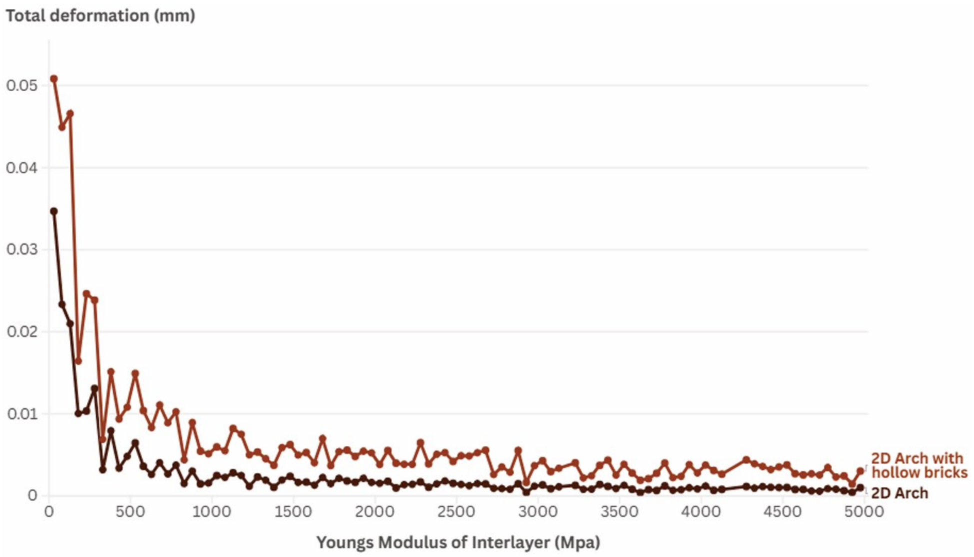
Results- 2D Arch (SOLID)



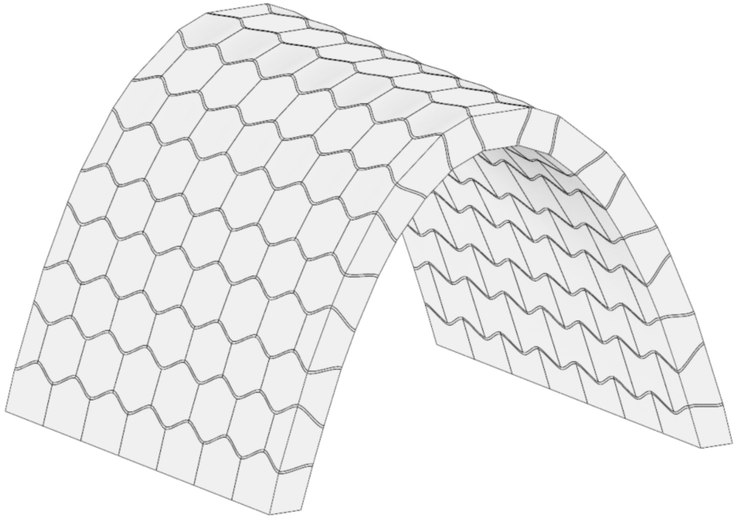
Interlayer Young's Modulus [...	Arch thickness	interlayer thic...	Total Deformat...	Max Prin Stres...	Max Prin Stres...	Minimum Prin...	Minimum Prin...	Rating	scid
180	170	12	0.010030154	133930.9194	356.0436847	-154887.323	-29327.44717	0	88
80	280	14	0.023334793	136190.5343	349.1011073	-240128.5893	-29290.62209	0	78

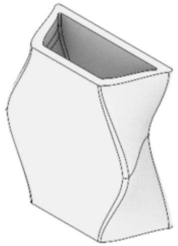
Results- 2D Arch

	(i)	(t)	(E)	(d)	(s1)	(s2)
Max Tensile stress- interlayer (s2)	-0.21	-0.02	0.41	-0.20	0.04	1.00
Max Tensile stress- glass (s1)	-0.05	0.07	-0.25	0.41	1.00	0.04
Total Deformation Maximum (d)	0.03	0.07	-0.51	1.00	0.41	-0.20
Youngs Modulus of interlayer (E)	0.00	0.01	1.00	-0.51	-0.25	0.41
Arch thickness (t)	-0.01	1.00	0.01	0.07	0.07	-0.02
Interlayer thickness (i)	1.00	-0.01	0.00	0.03	-0.05	-0.21

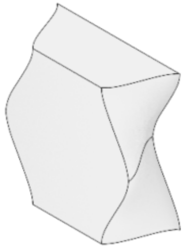


Finite Element Analysis ON DISCRETE MODEL of the Simplified Catenary Vault





2450kg/cu.m



1403kg/cu.m

PARAMETERS

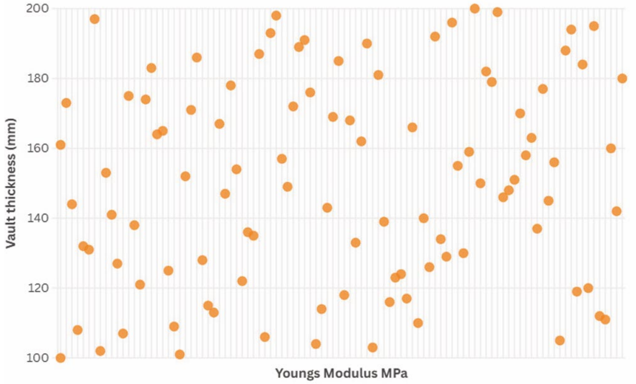
Width of Masonry unit (thickness of vault/arch)

~~Thickness of the interlayer (*t*)~~

Area of the interlayer (*A*)

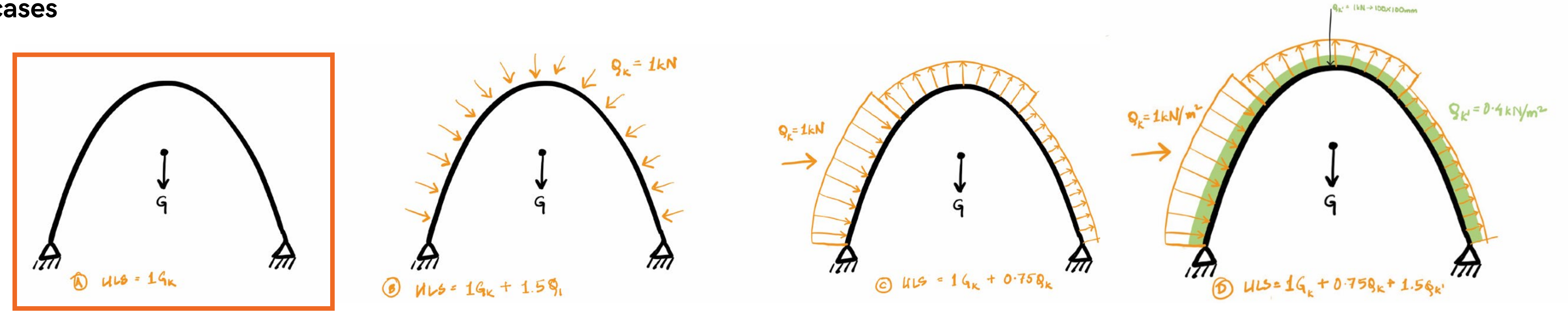
Material property of the interlayer (*E*)

THE DESIGN SPACE:



GEOMETRY	INPUT				OUTPUT		OPTIMIZATION	
	Variables/ Constants	Bounds		Design samples	Response	Objective	Constraints	Limit State
Catenary Vault				100	Max Tensile Stess in glass	minimize	none	Max Tensile Stress in glass<30MPa
	Arch thickness (T) in mm	100	200		Total deformation	minimize		
	Interlayer thickness (I) in mm		10		Max Tensile Stress in Interlayer			
	Interlayer Young's Modulus (E) in Mpa	20	2000		Max Compressive Stresses			

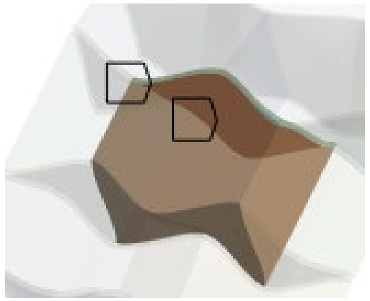
Load cases



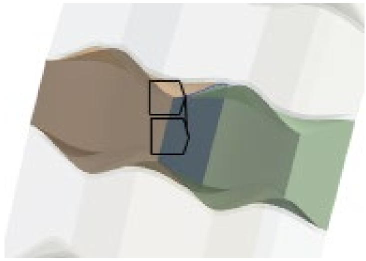
	Design Points		Optimization	Surrogate Model	
Geometry	Load condition	Design samples	Objectives	Coefficient of Prognosis	Remarks
Catenary Vault	A. Self Weight	100	1. Minimize Tensile stress in glass	97%-99%	Clear relationship between input/output parameters
	B. Self Weight + Uniform maintenance load of 1kN/sqm	100	2. Minimize Total deformation	0-29%	Relationship between the inputs and outputs not clear to be represented by a surrogate model.
	C. Self Weight + Pressure load due to wind of 1kN/sqm on one side	100		0-62%	
	D. Self Weight + Pressure load due to wind of 1kN/sqm on one side + Uniform Maintenance load of 0.4kN/sqm + Maintenance Point load of 1kN over 100mm x 100mm area at the center of vault	200		3-11%	

Boundary conditions

Contacts



Frictional



Frictionless

Materials

glass

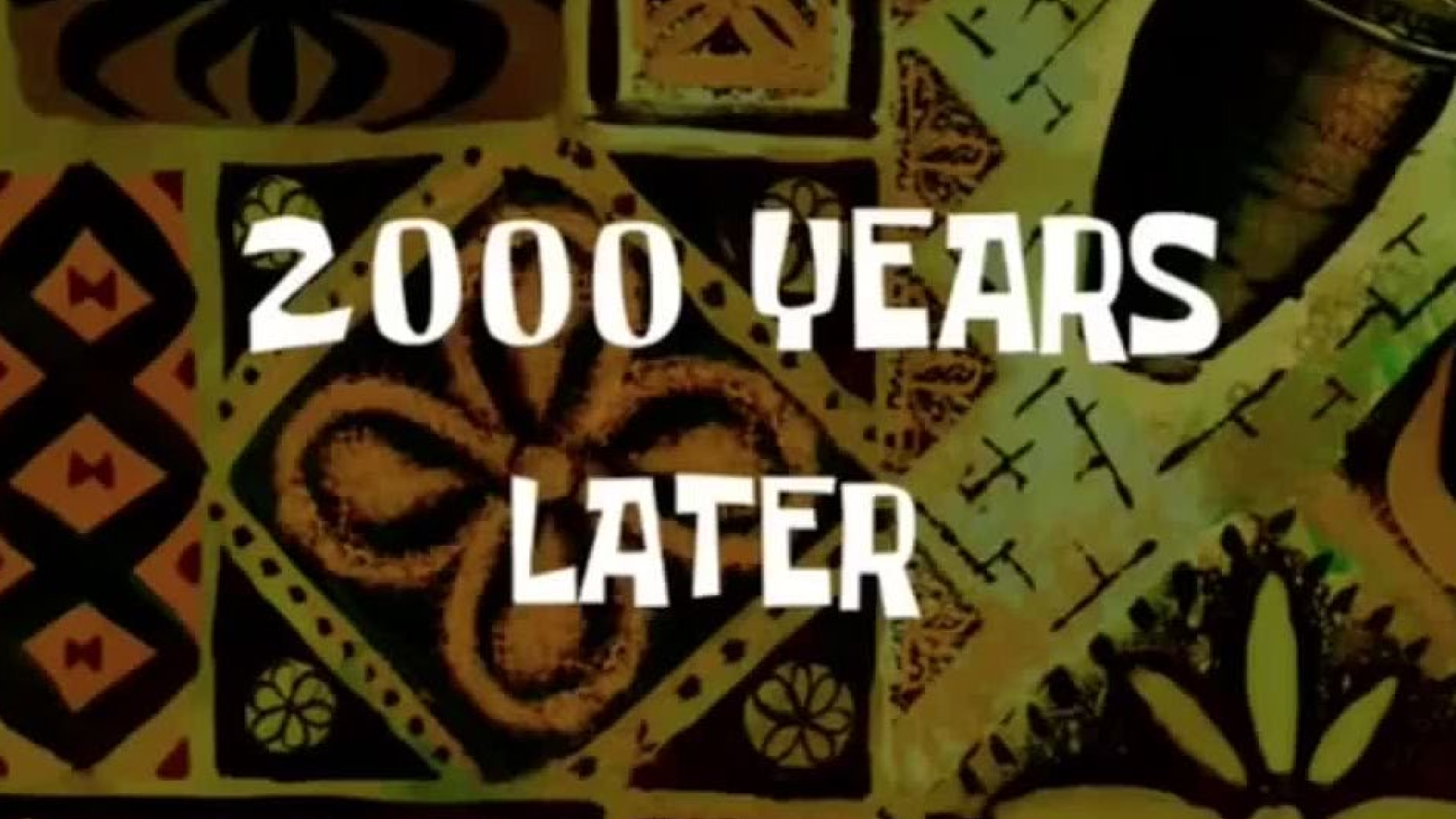
Soda-lime glass (Corning 0080)

Data compiled by Ansys Granta, incorporating various sources including JAHM and MagWeb.
ANSYS, Inc. provides no warranty for this data.

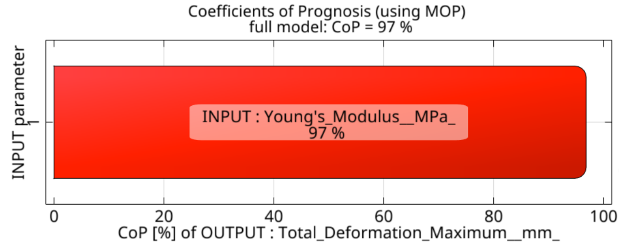
Density	1403,0 kg/m³

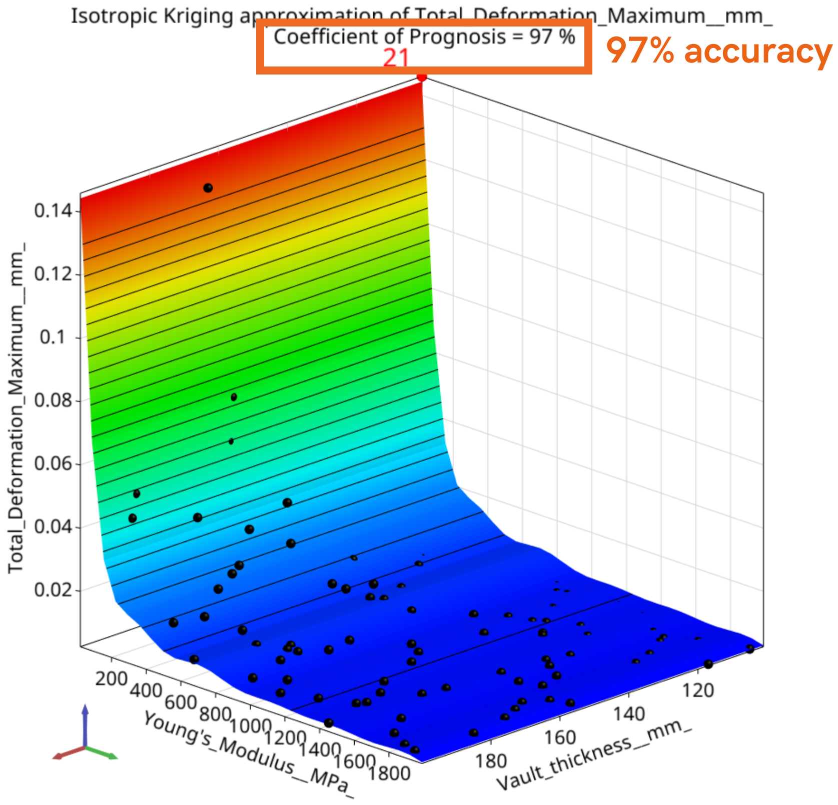
interlayer

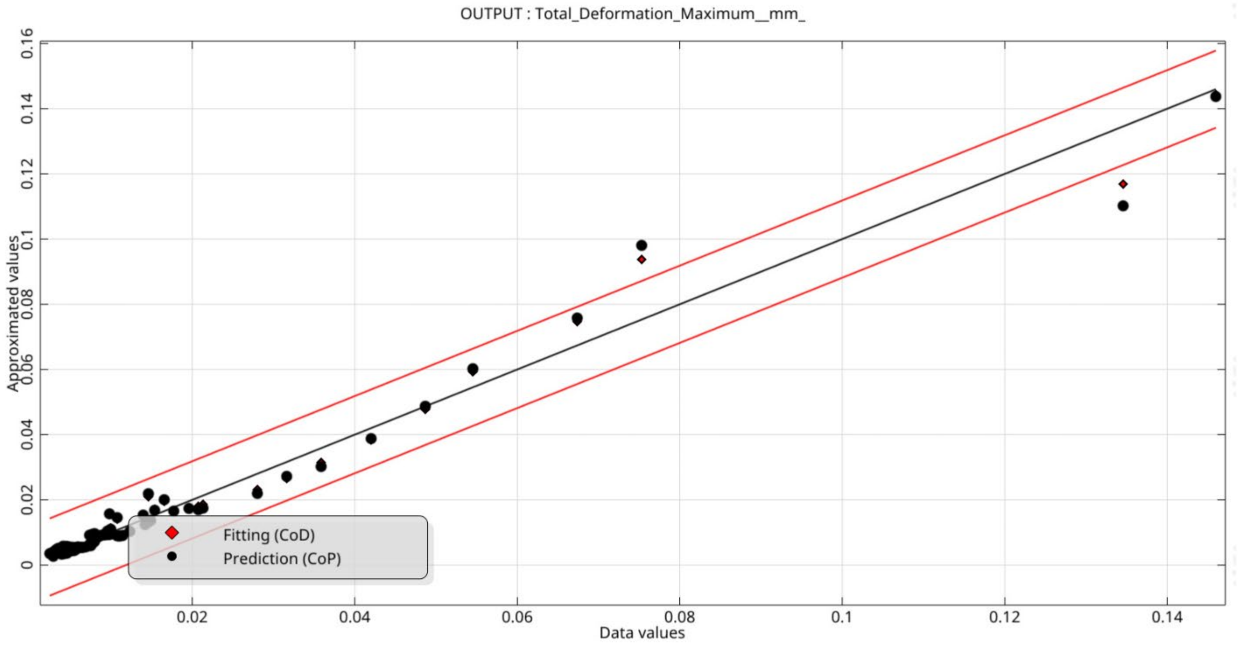
Density	1100,0 kg/m³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	5e+07 Pa
Poisson's Ratio	0
Bulk Modulus	1,6667e+07 Pa
Shear Modulus	2,5e+07 Pa


2000 YEARS
LATER

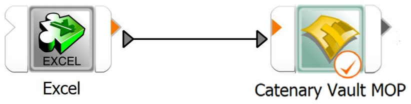
Response Surface Approximation of output- Total Deformation (in mm)
inputs- Young's Modulus of Interlayer
Thickness of Vault



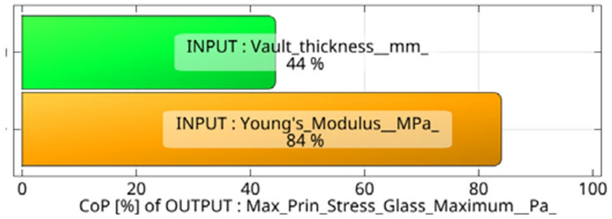


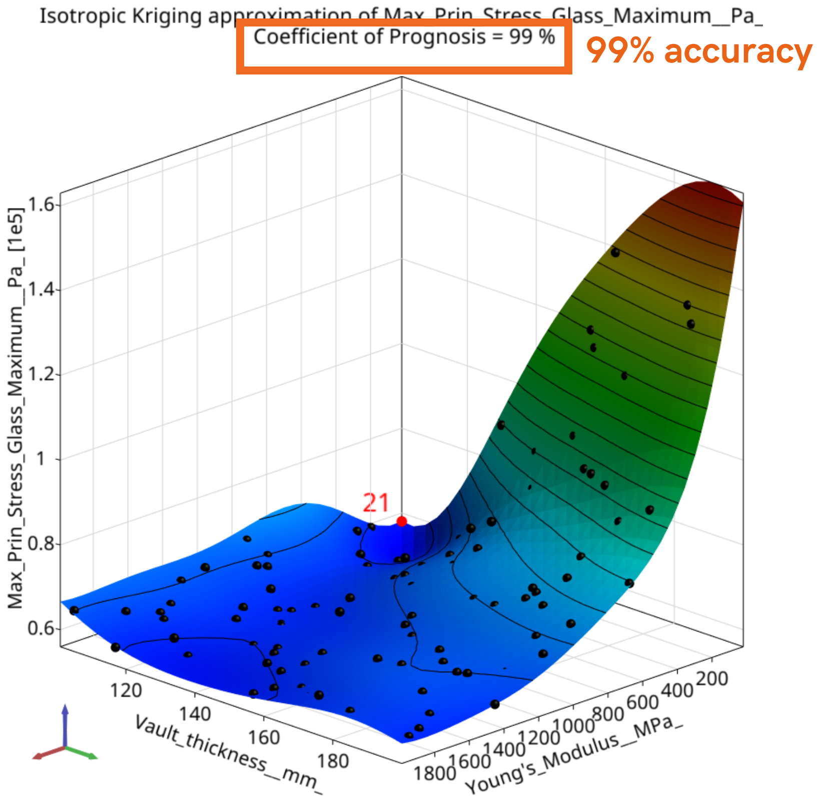


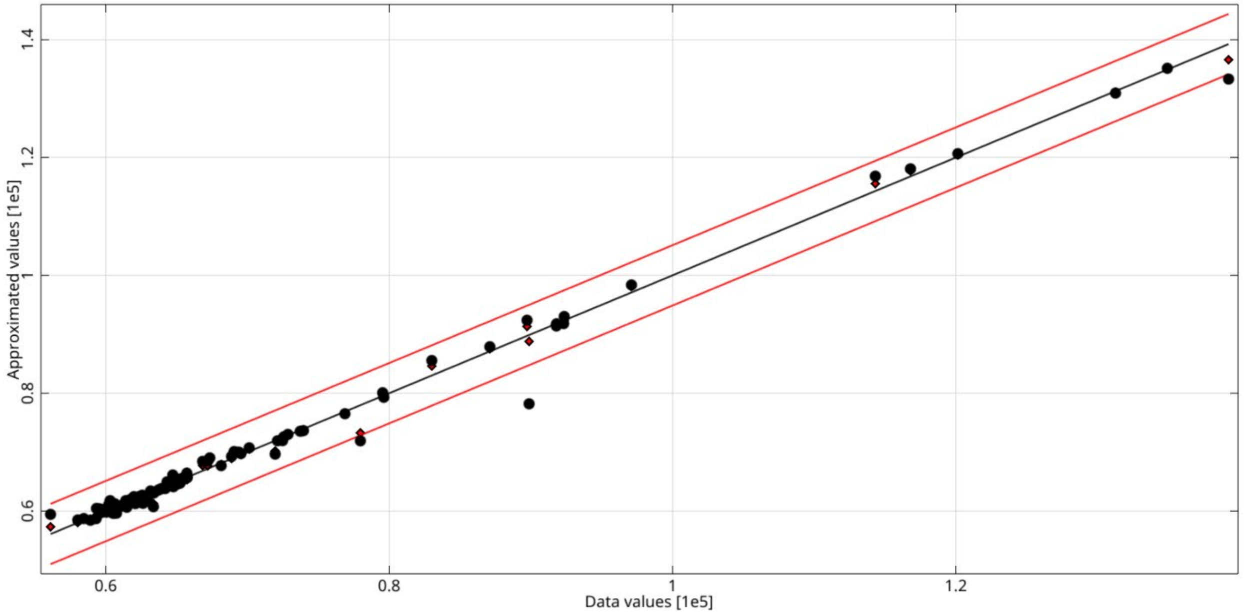
Prediction errors		Fitting errors	
Max Error:	0.0243489	Max Error:	0.0184468
Mean Error:	0.00180544	Mean Error:	0.00158605
Root Mean Square Error:	0.00394895	Root Mean Square Error:	0.00317854
CoP:	0.968378	CoD:	0.979513
		adjusted CoD:	0.979513



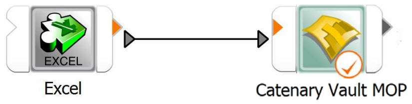
Response Surface Approximation of output- Max. Principle Tensile stress in Glass (Pa)
inputs- Young's Modulus of Interlayer
Thickness of Vault

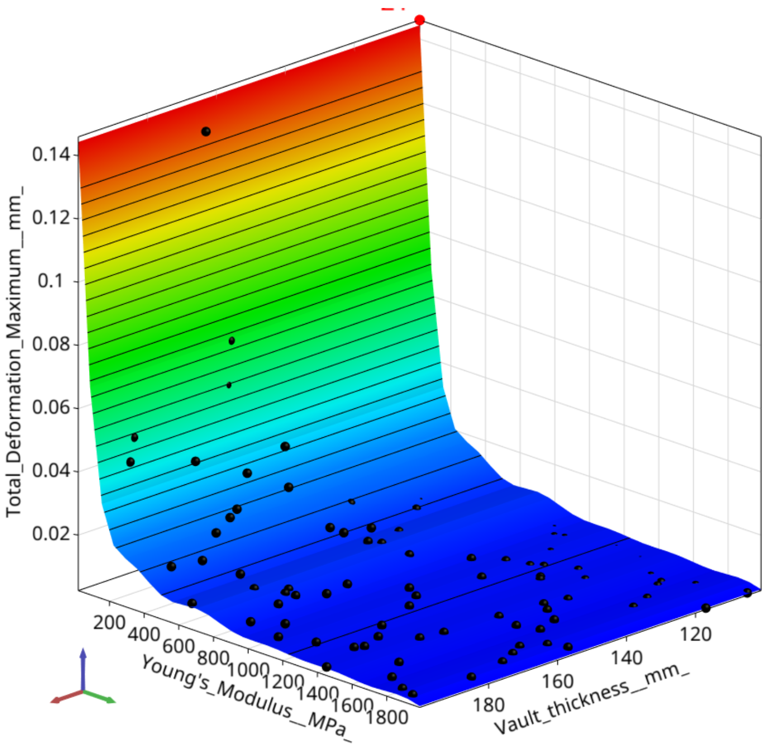


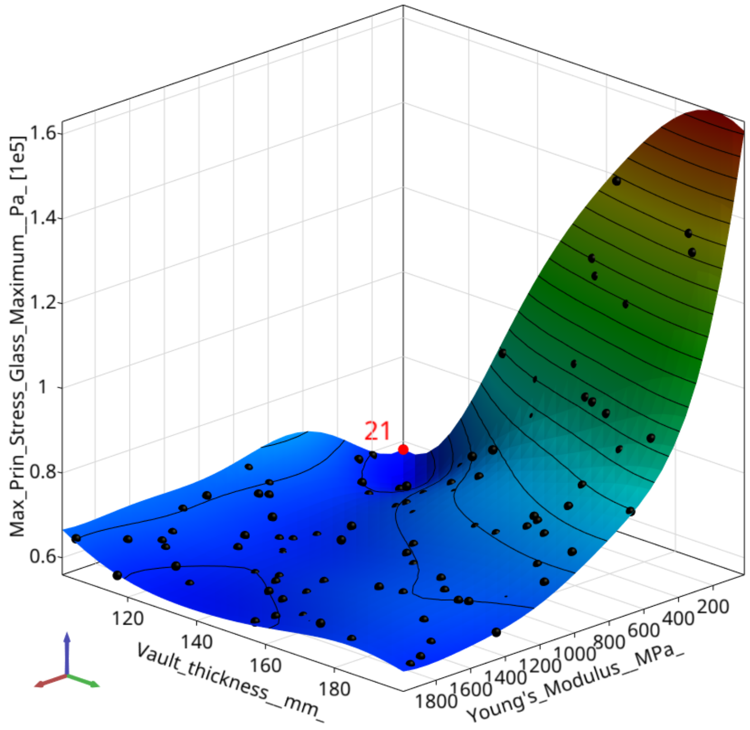




Prediction errors		Fitting errors	
Max Error:	11669.3	Max Error:	4699.23
Mean Error:	860.071	Mean Error:	505.531
Root Mean Square Error:	1706.15	Root Mean Square Error:	817.754
CoP:	0.9897	CoD:	0.997634
		adjusted CoD:	0.997634







Properties

↕

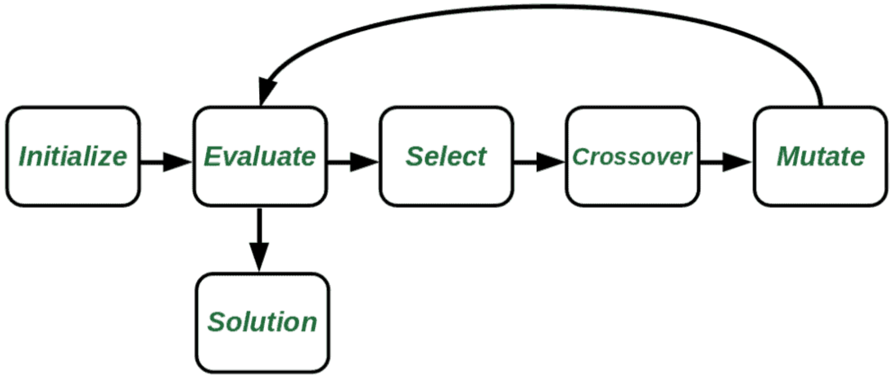
Structural performance

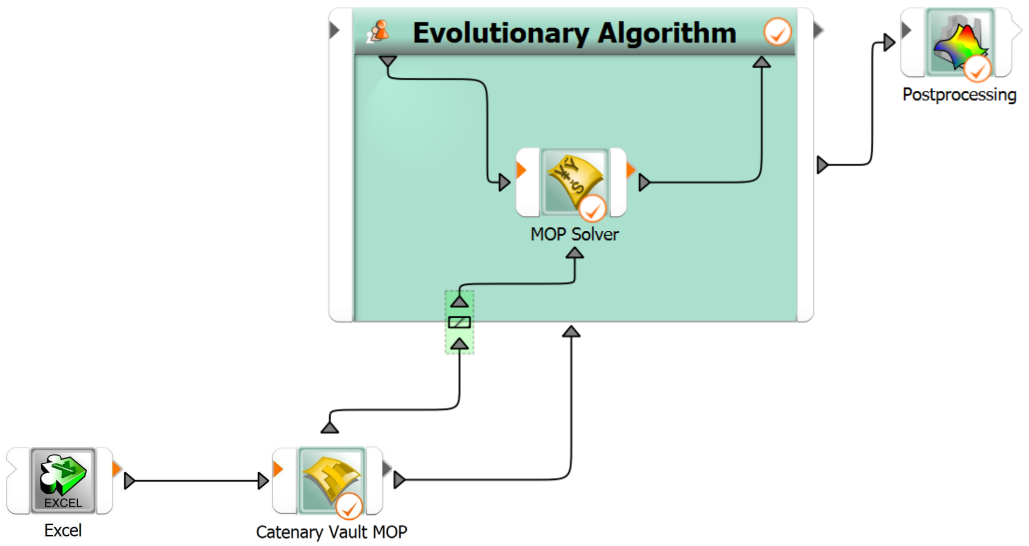
Inputs- **Young's Modulus of Interlayer**
Thickness of Vault
Responses- Max. Principle Tensile stress in Glass
Max. total deformation

Optimization objectives:

- Minimize Total Deformation maximum
- Minimize Maximum Tensile stress in glass

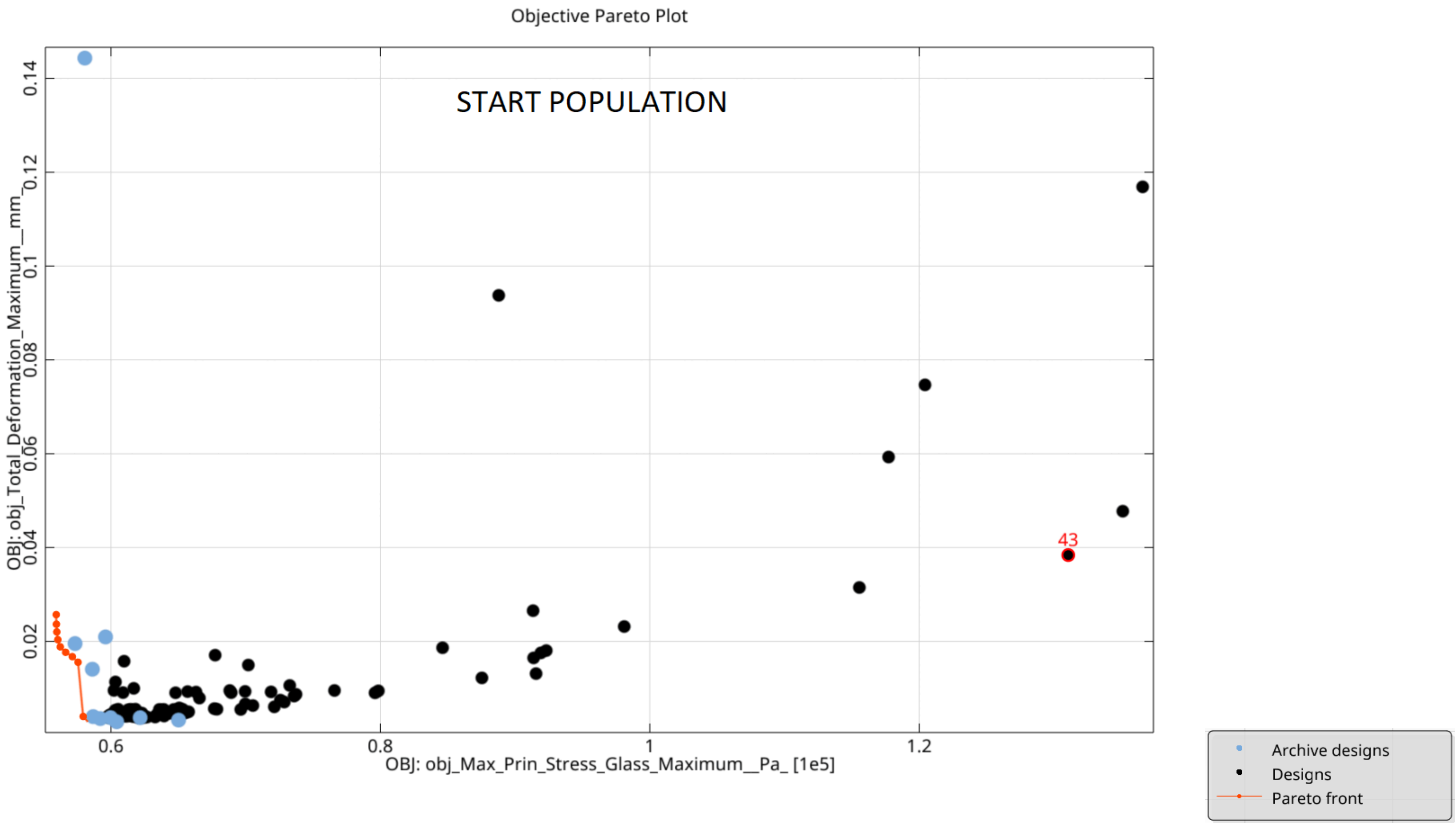
Evolutionary Algorithm:



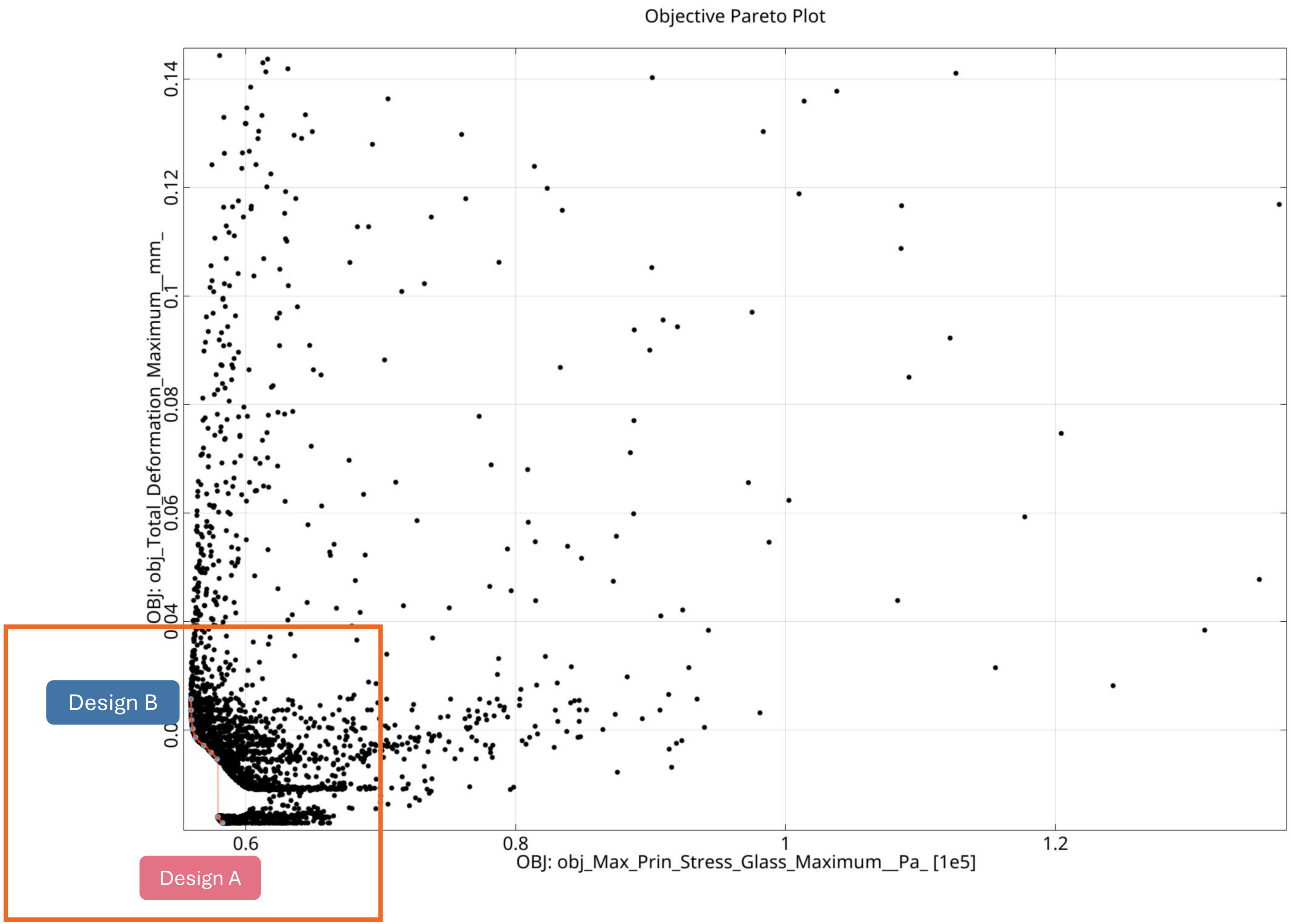


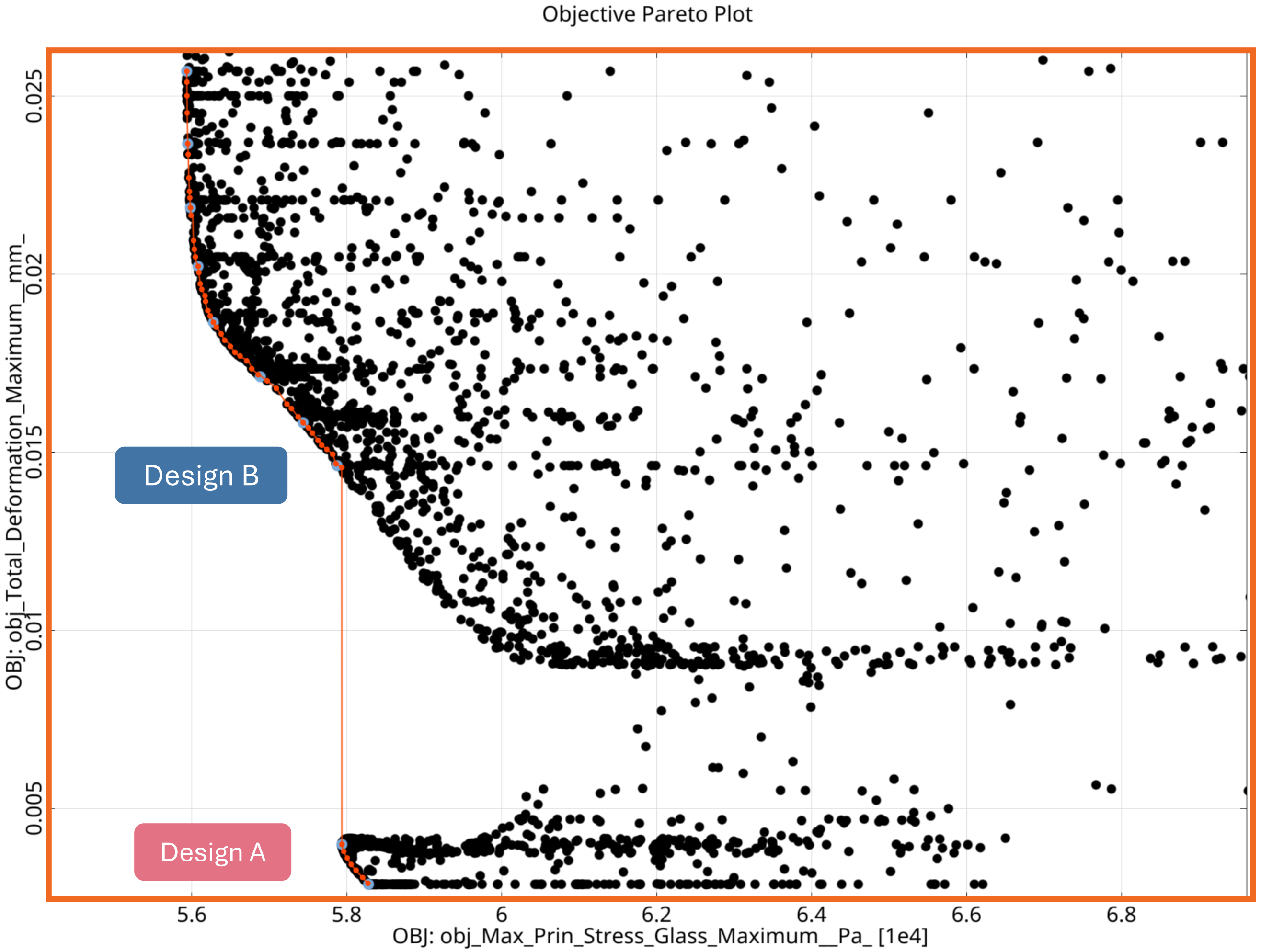
Population size: 10 Start population size: 10
Maximum number of generations: 1000
Number of stagnation generations: 20
Mutation rate: 50%
Fitness method: Pareto dominance

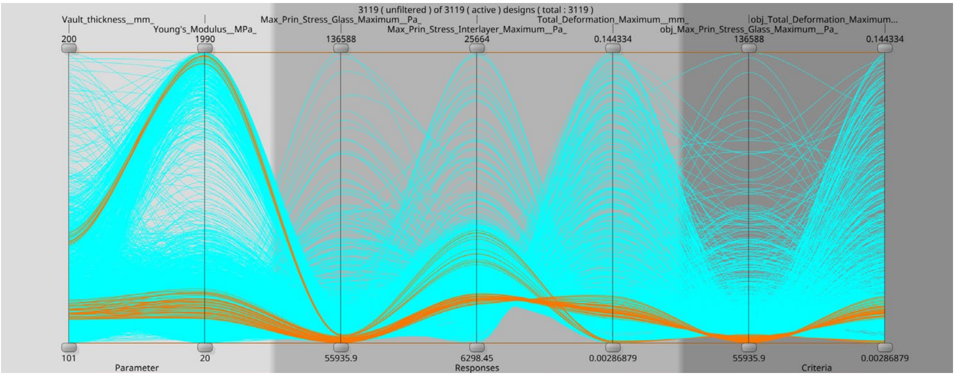
Optimization

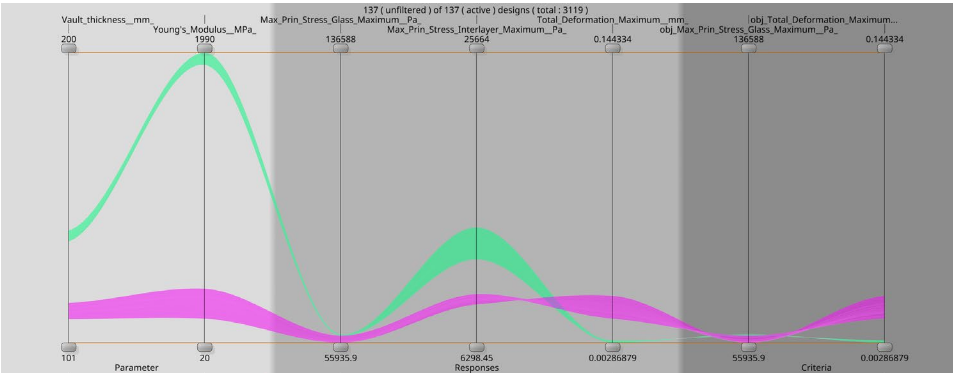

Objective Pareto Plot
START POPULATION
0.14
0.12
0.1
0.08
0.06
0.04
0.02
OBJ: obj_Total_Deformation_Maximum__mm_
0.6
0.8
1
1.2
OBJ: obj_Max_Prin_Stress_Glass_Maximum__Pa_ [1e5]
43
Archive designs
Designs
Pareto front

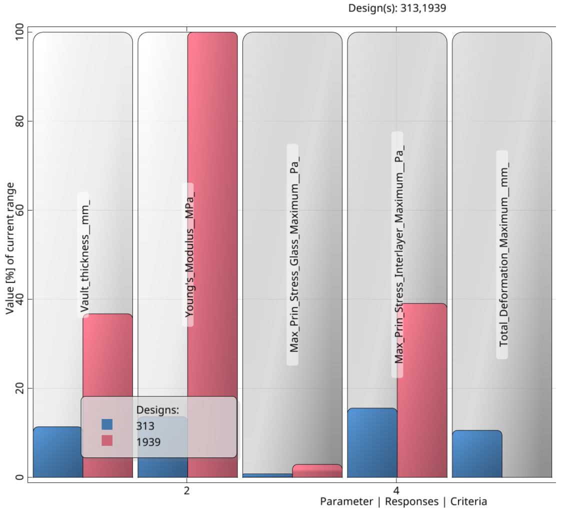
3119 designs evaluated <1min





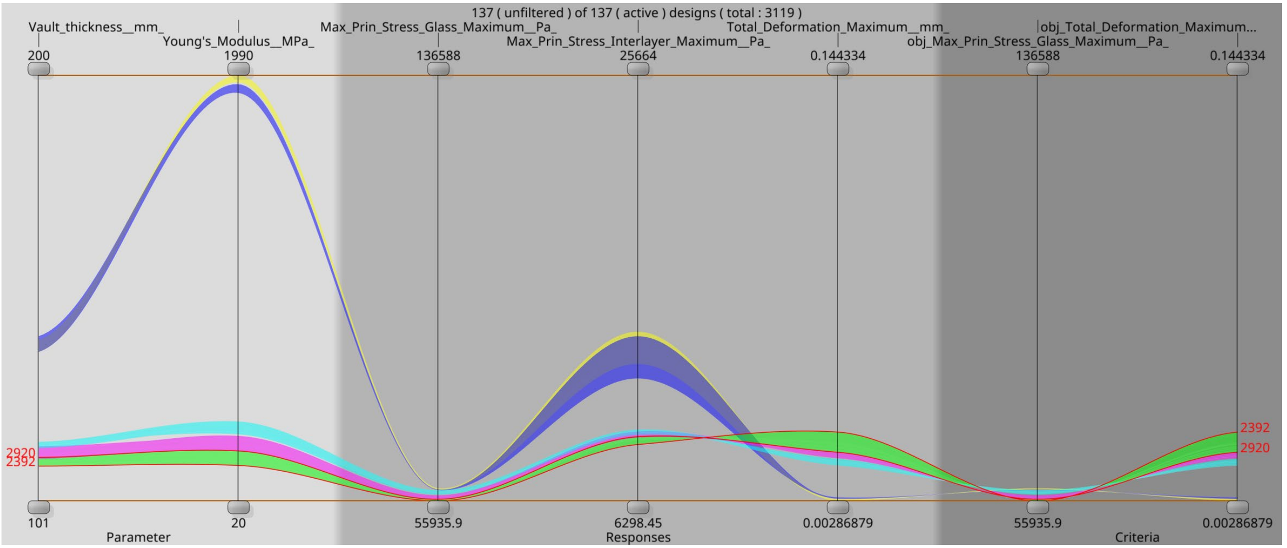


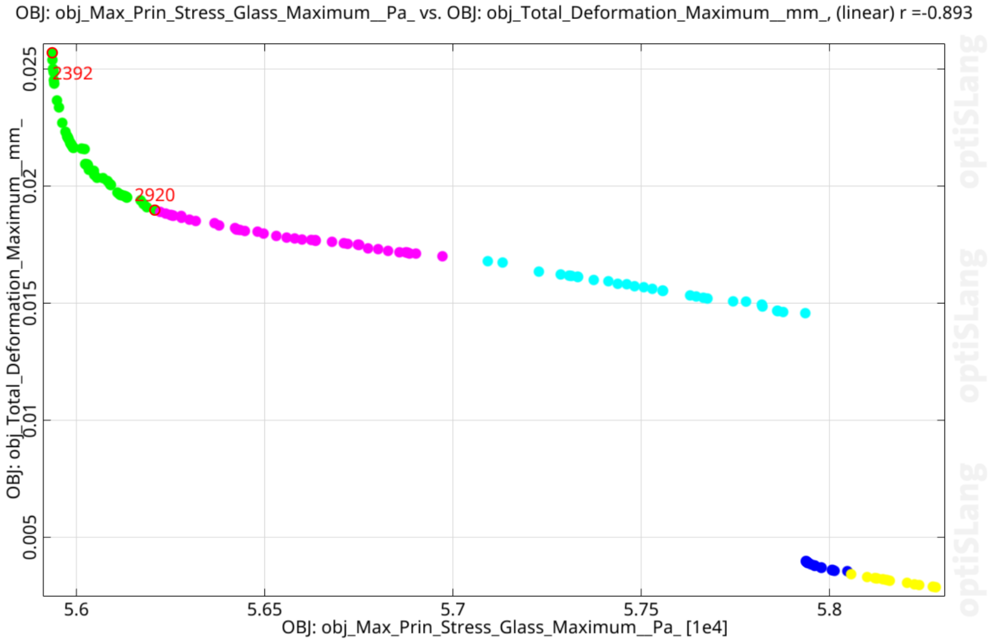




Design A

Design B





Design 2392: E = 183.333MPa; t = 109.06mm

Design 2920: E = 250.493MPa; t = 111.086mm

Validation:

Design Inputs			Responses	
	Young's Modulus of the Interlayer(Mpa)	Vault Thickness (mm)	Total Deformation (mm)	Maximum Tensile stress in glass (MPa)
2392			Response Predicted	
	183.333	109.06	0.026	0.055936
			Actual (FEA)	
	183	109	0.015	0.044837
2920			Response Predicted	
	250.493	111.086	0.018	0.056208
			Actual (FEA)	
	250	111	0.010	0.041524

Table 8: Predicted and Actual results

0.011MPa = 11000Pa

0.015MPa = 15000Pa

Total Deformation (mm):

Prediction errors	
Max Error:	0.0243489
Mean Error:	0.00180544
Root Mean Square Error:	0.00394895
CoP:	0.968378

Max Tensile stress in glass (in Pa):

Prediction errors	
Max Error:	11669.3
Mean Error:	860.071
Root Mean Square Error:	1706.15
CoP:	0.9897

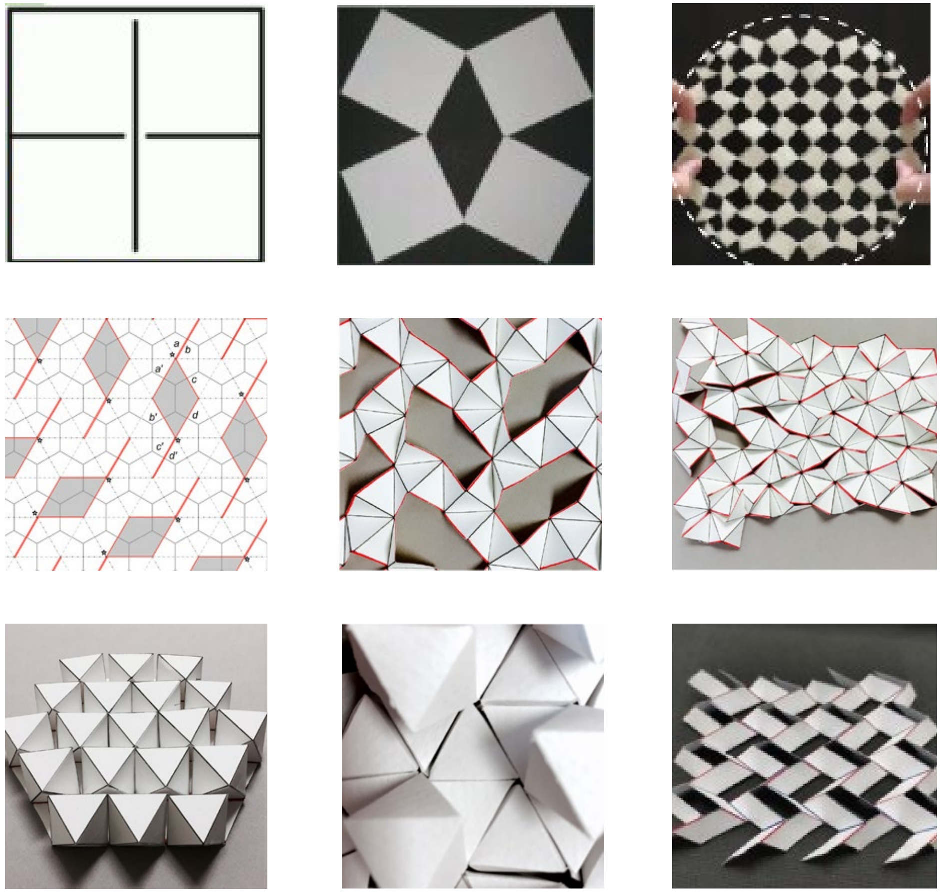
Thickness of the vault: 109 to 111 mm

Required interlayer: 183 to 250 MPa

Required interlayer: 183 to 250 MPa

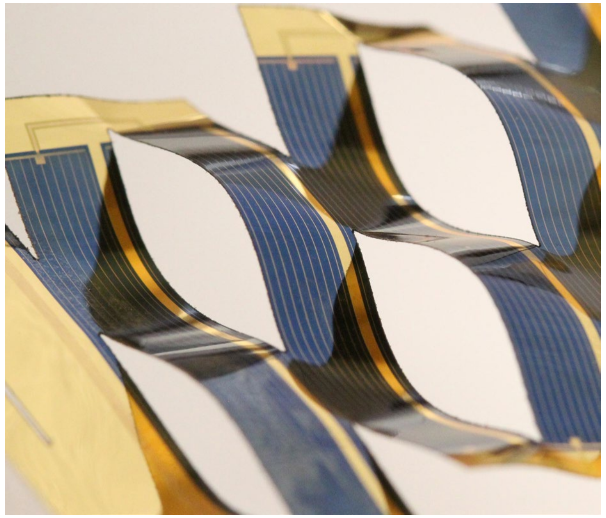
Create a material to achieve the target properties

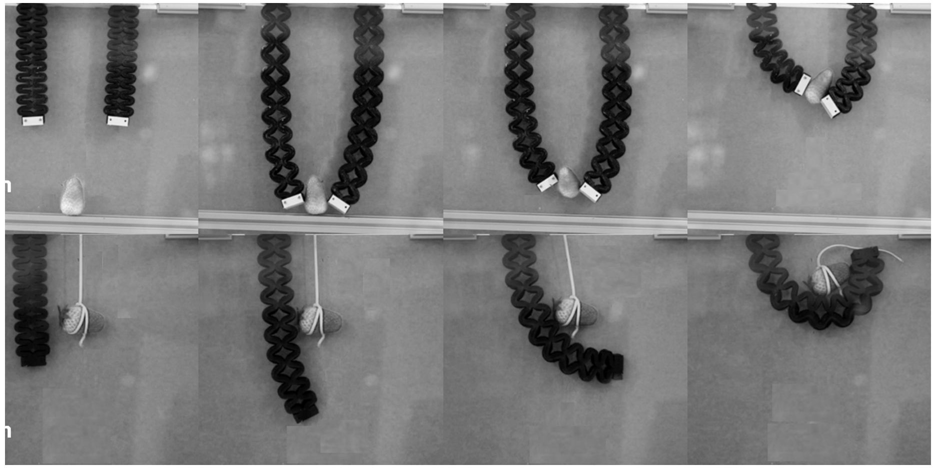
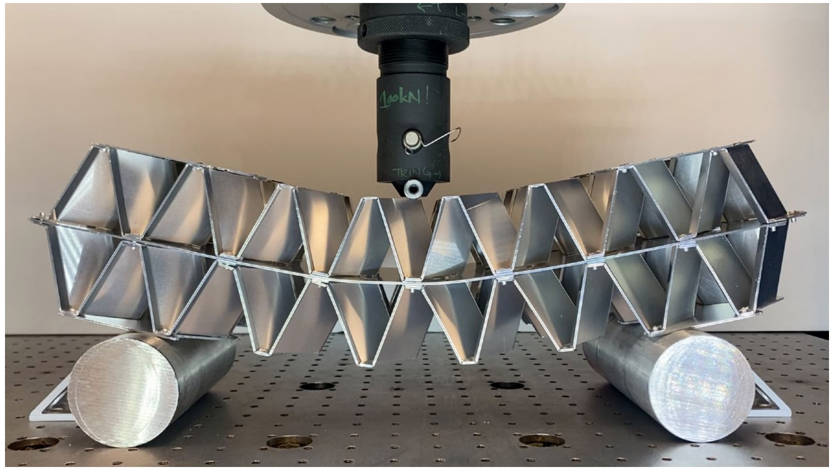
KIRIGAMI



https://imechanica.org/node/24988

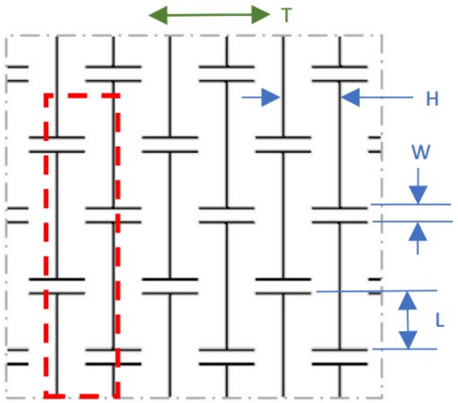
Kirigami - applications

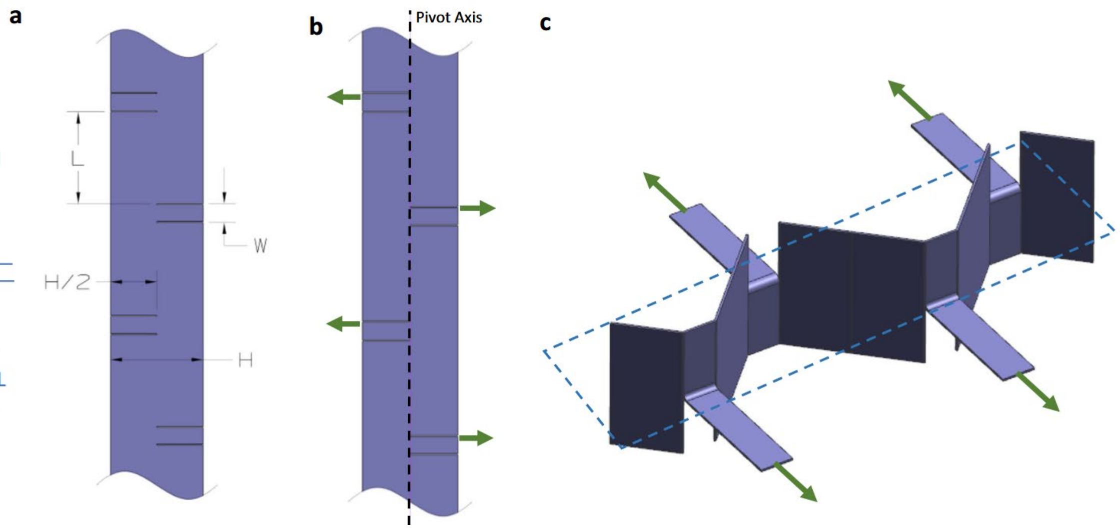



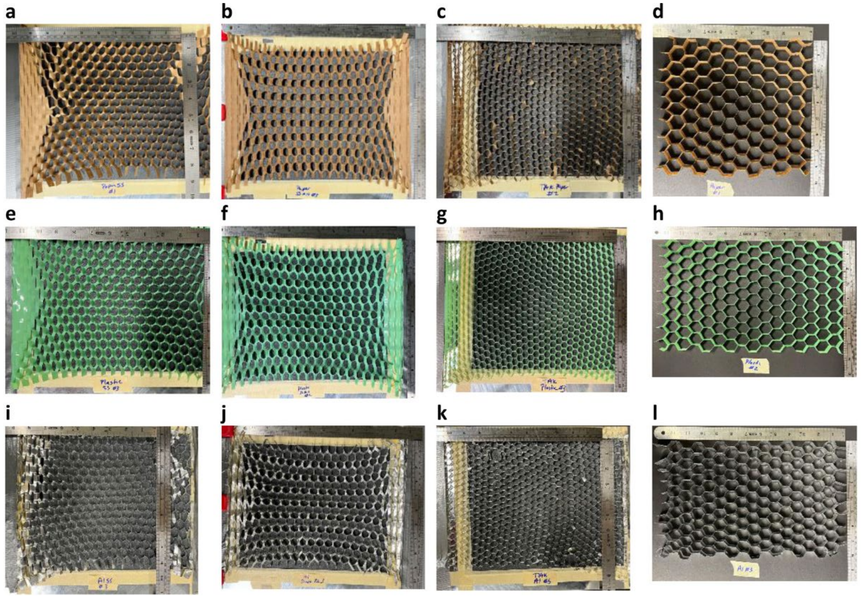



https://www.advancedsciencenews.com/kirigami-inspired-gripper-handles-drops-of-water/
https://liebertpub.com/doi/abs/10.1089/soro.2021.0199?journalCode=soro
http://www.expandedperforatedmetal.com/products/expanded-metal-grating.html
https://ece.engin.umich.edu/stories/art-inspired-solar-cells

Tension Activated Kirigami (TAK)

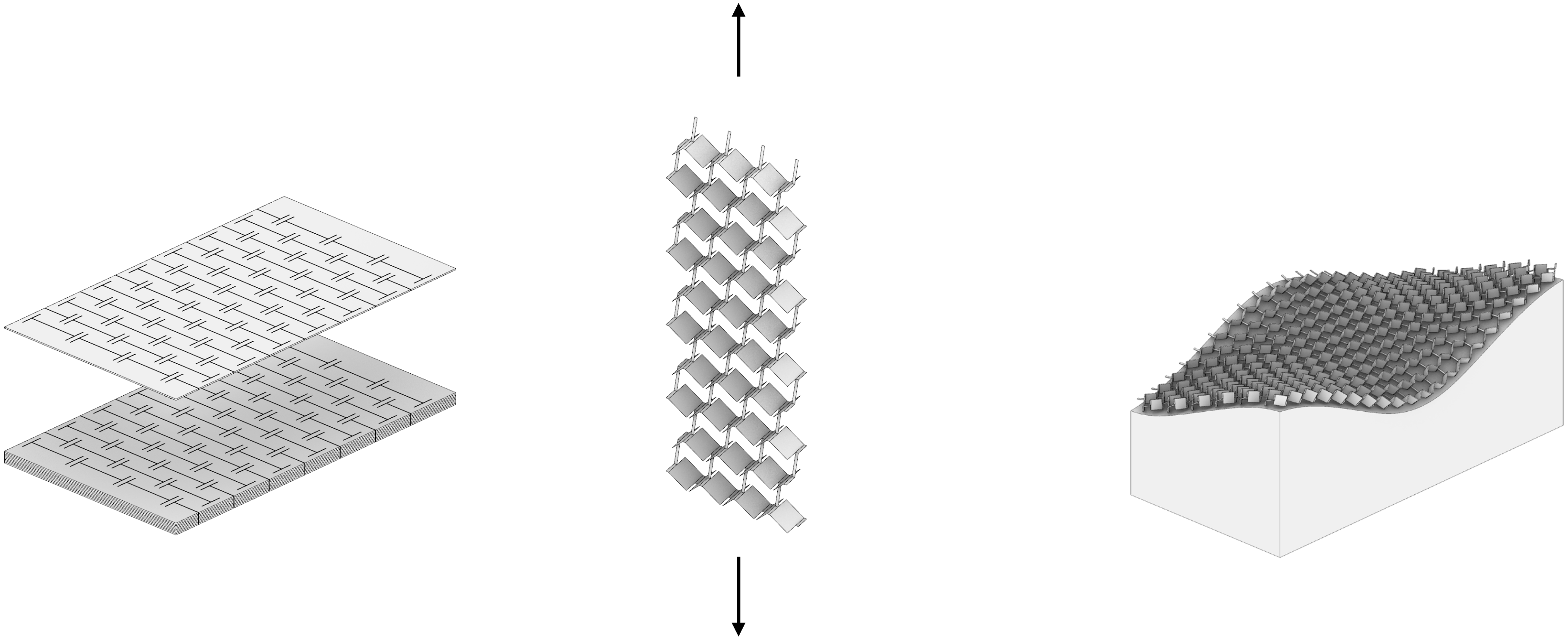




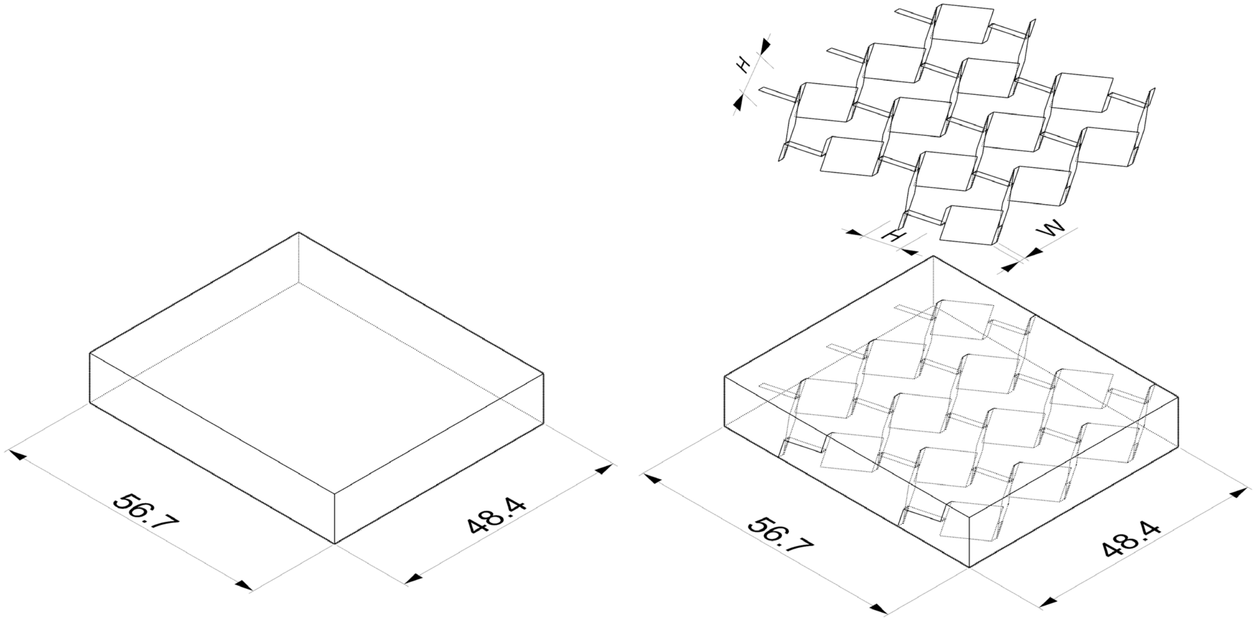


-Corrigan et al., 2023

Tension Activated Kirigami (TAK) for the interlayer



$$k = \frac{EA}{t}$$



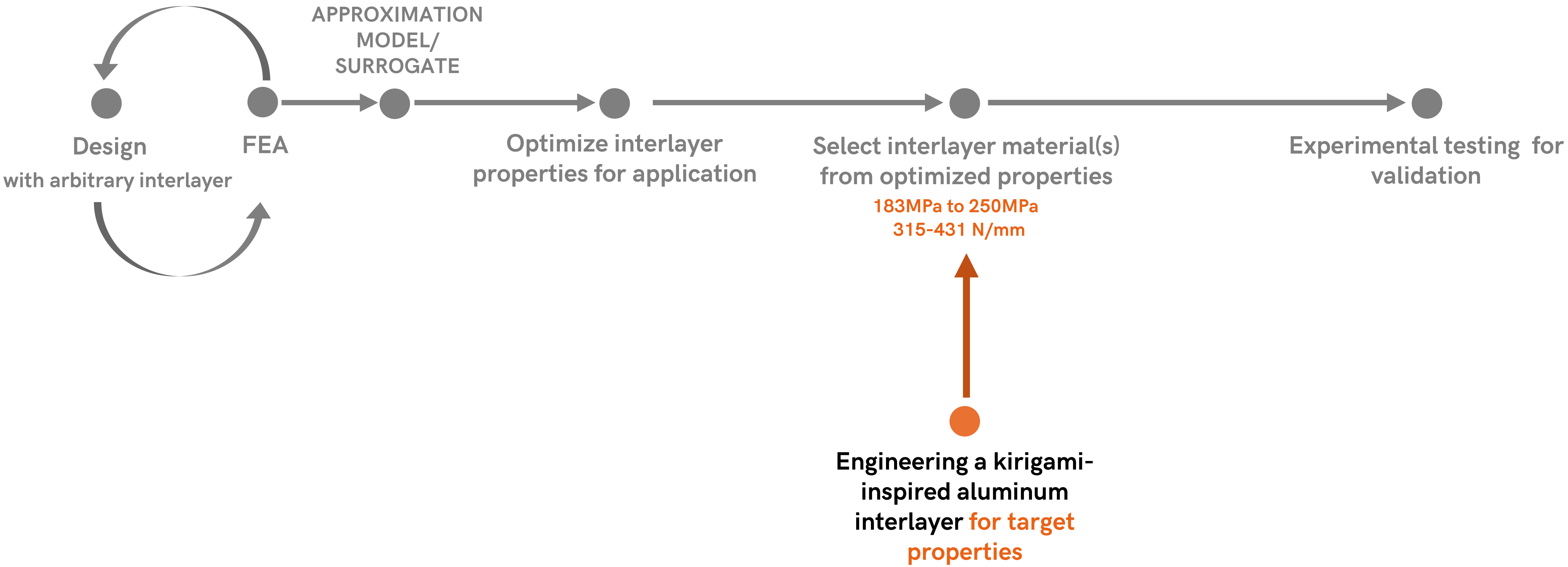
$$k = F_z/\delta_z$$

Stiffness Range for the kirigami interlayer: 315 to 431 N/mm

Solid interlayer range for selected catenary vault best designs			
Youngs Modulus [Mpa] E	Density [kg/cu.m]	Thickness [mm] t	Stiffness [N/mm]
183	1100	10	315
250	1100	10	431

Table 9: Target stiffness range for the interlayer

Stiffness range



Proposed Method

APPROXIMATION MODEL/ SURROGATE

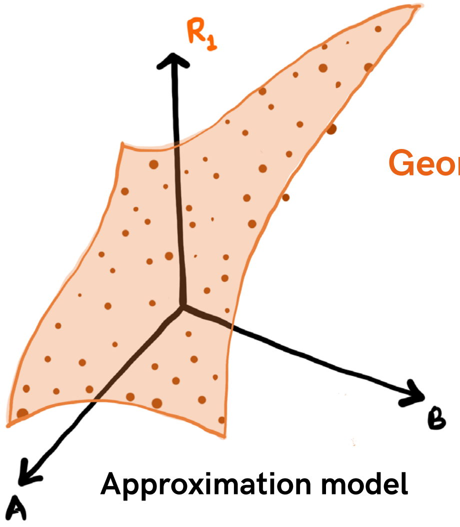
Design with arbitrary interlayer → FEA → Optimize interlayer properties for application → Select interlayer material(s) from optimized properties → Experimental testing for validation

183MPa to 250MPa

Optimization

FEA

Tension Activated Kirigami geometries

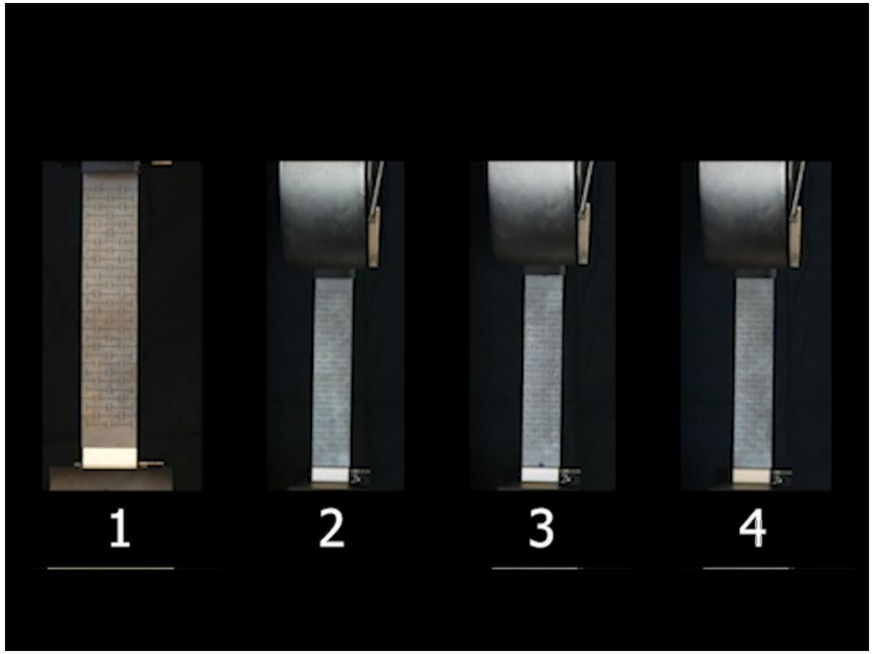


Geometry properties

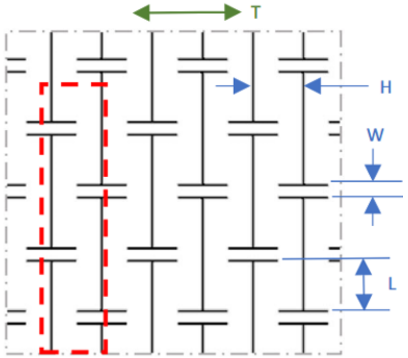
Stiffness

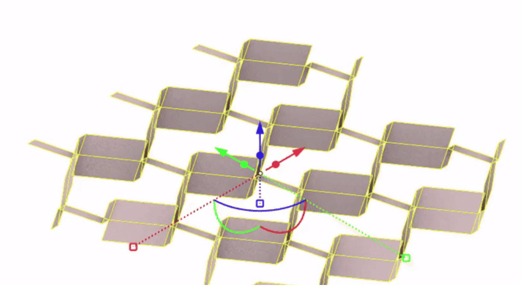
Approximation model

Proposed Method

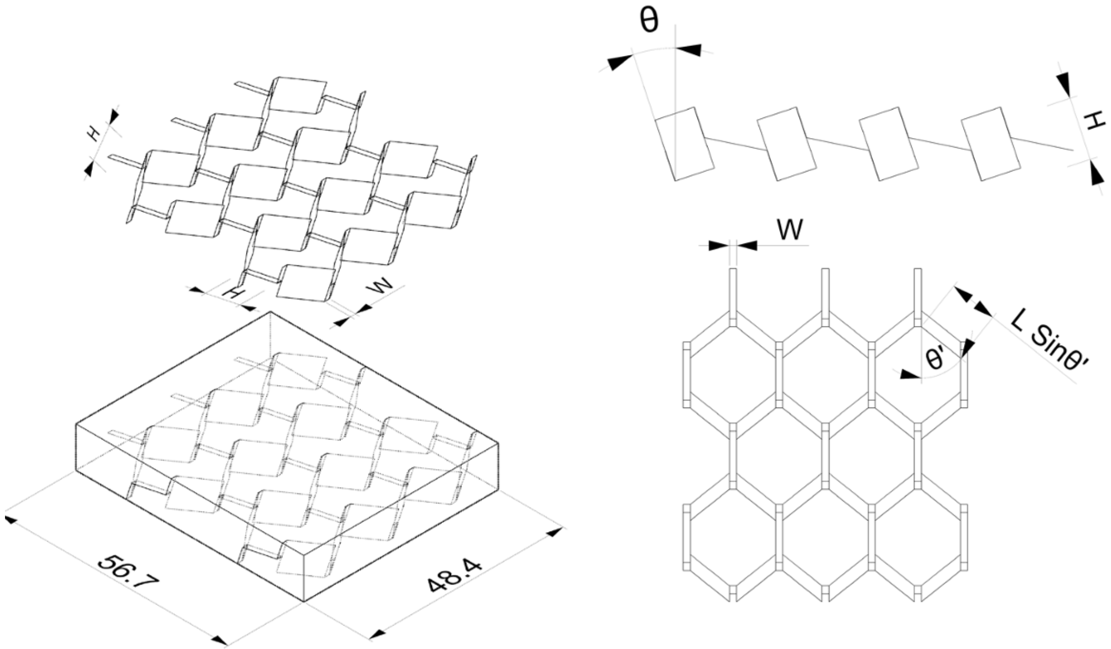


Activation and compression tests
@ Fabrication-Integrated Design Lab MIT





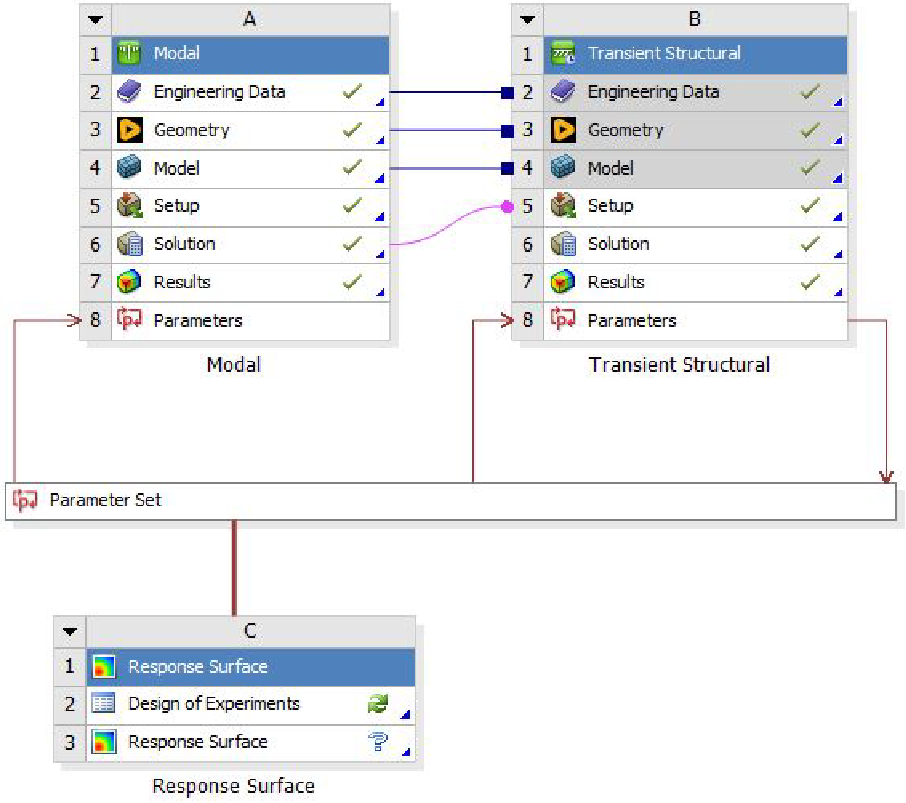
Reference dimensions: L = 5.8 mm, H = 5.8 mm, W = 1.2 mm

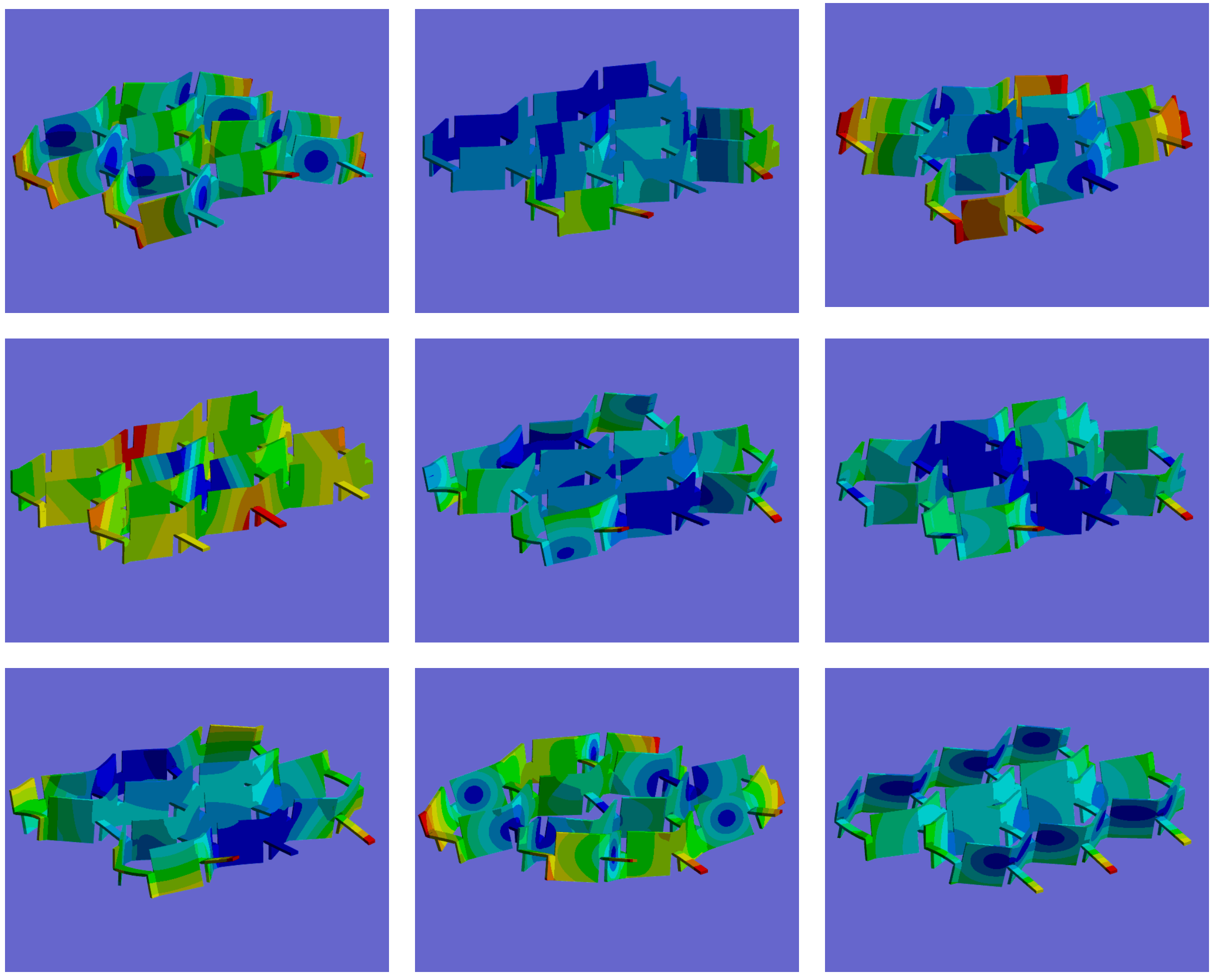


Variable parameters: H=L and thickness of sheet

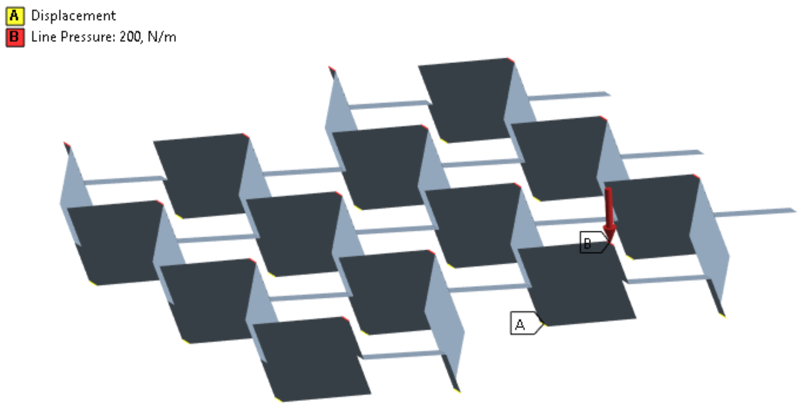
Activated Kirigami Parametric model

ANSYS WORKBENCH





Boundary conditions



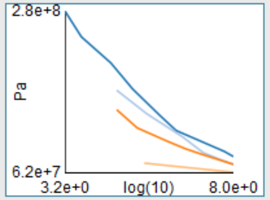
$$k = F_z / \delta_z$$

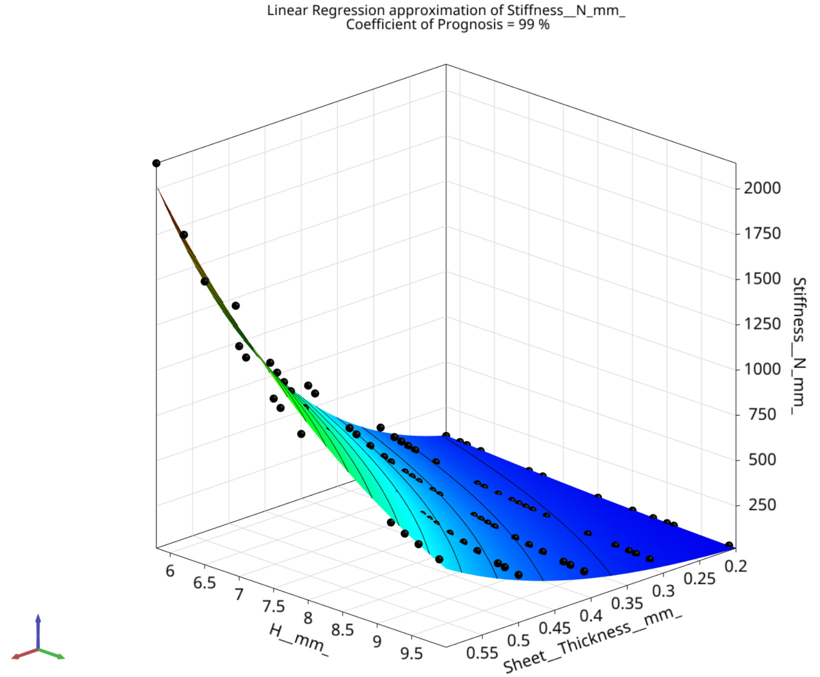
Materials

Aluminum Alloy

General aluminum alloy. Fatigue properties come from MIL-HDBK-5H, page 3-277.

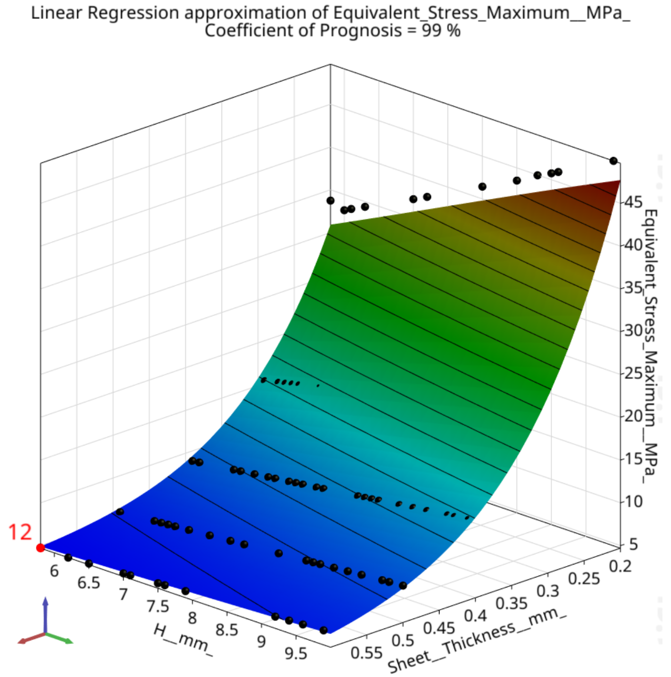
Density	2770,0 kg/m³

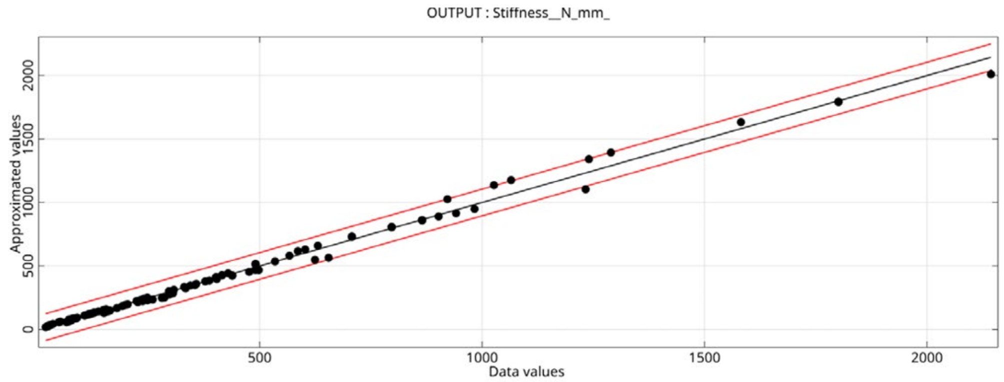
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	7,1e+10 Pa
Poisson's Ratio	0,33000
Bulk Modulus	6,9608e+10 Pa
Shear Modulus	2,6692e+10 Pa
Isotropic Secant Coefficient of Thermal Expansion	2,3e-05 1/°C
Compressive Ultimate Strength	0 Pa
Compressive Yield Strength	2,8e+08 Pa
S-N Curve	
Tensile Ultimate Strength	3,1e+08 Pa
Tensile Yield Strength	2,8e+08 Pa



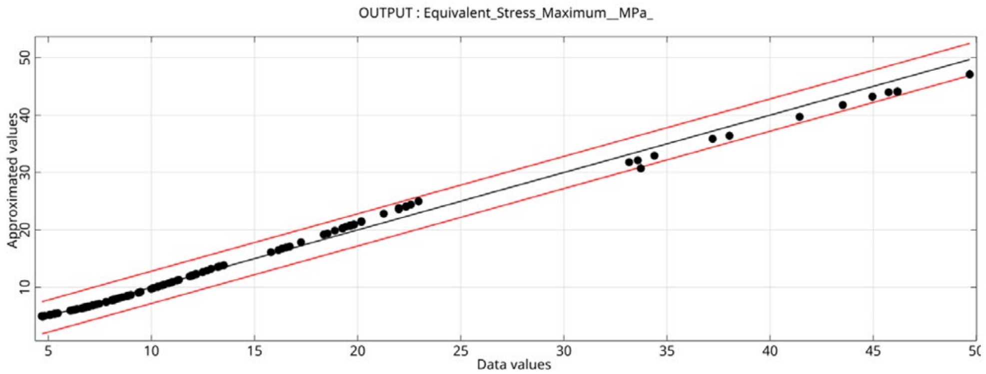
Geometry properties

Stiffness

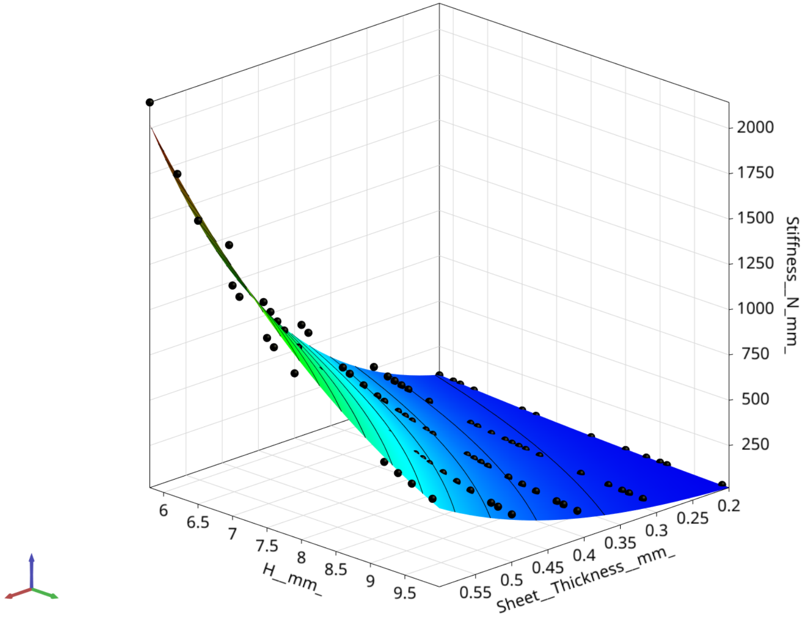


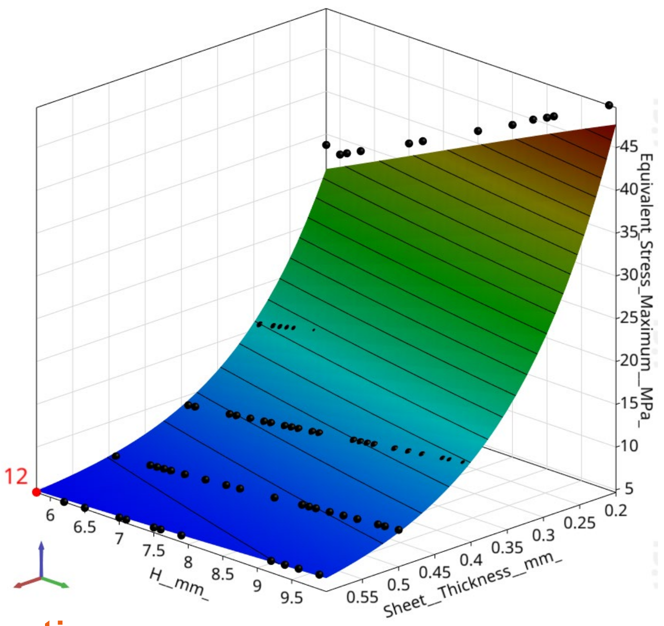


Prediction errors		Fitting errors	
Max Error:	133.274	Max Error:	127.72
Mean Error:	19.1555	Mean Error:	19.0166
Root Mean Square Error:	35.05	Root Mean Square Error:	34.6225
CoP:	0.993016	CoD:	0.993186
		adjusted CoD:	0.992975



Prediction errors		Fitting errors	
Max Error:	3.02697	Max Error:	2.80773
Mean Error:	0.652077	Mean Error:	0.644075
Root Mean Square Error:	0.935202	Root Mean Square Error:	0.914968
CoP:	0.992901	CoD:	0.993205
		adjusted CoD:	0.992922





Geometry properties

↕

Stiffness

Stiffness Range Target: 315 to 431 N/mm

REVERSE CALCULATING THE KIRIGAMI GEOMETRY

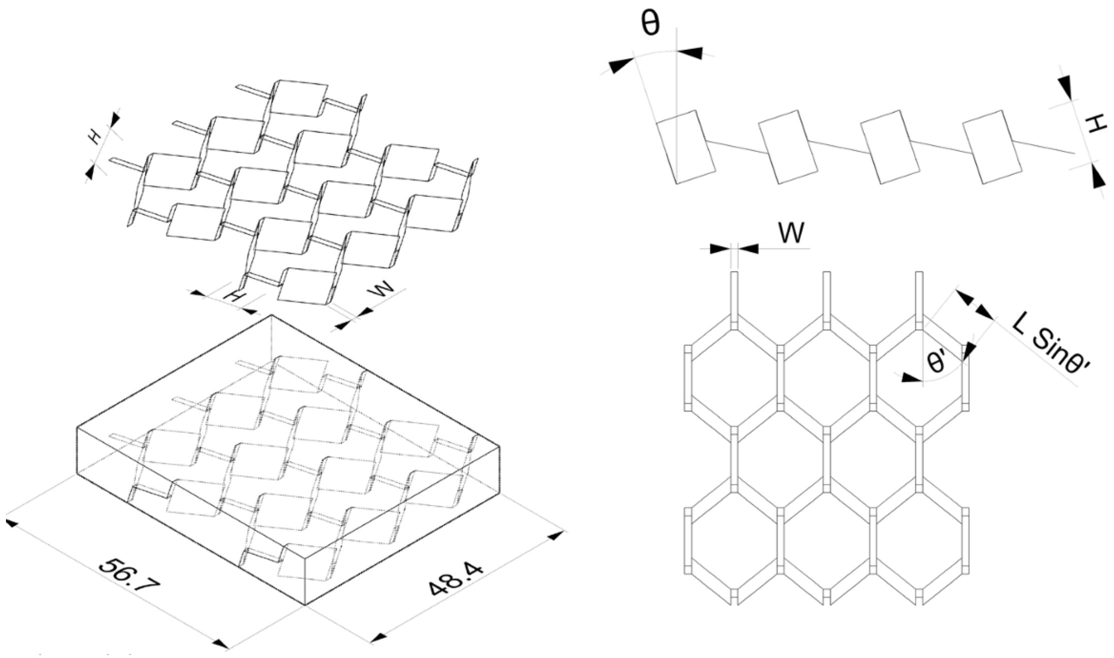
Constraint:

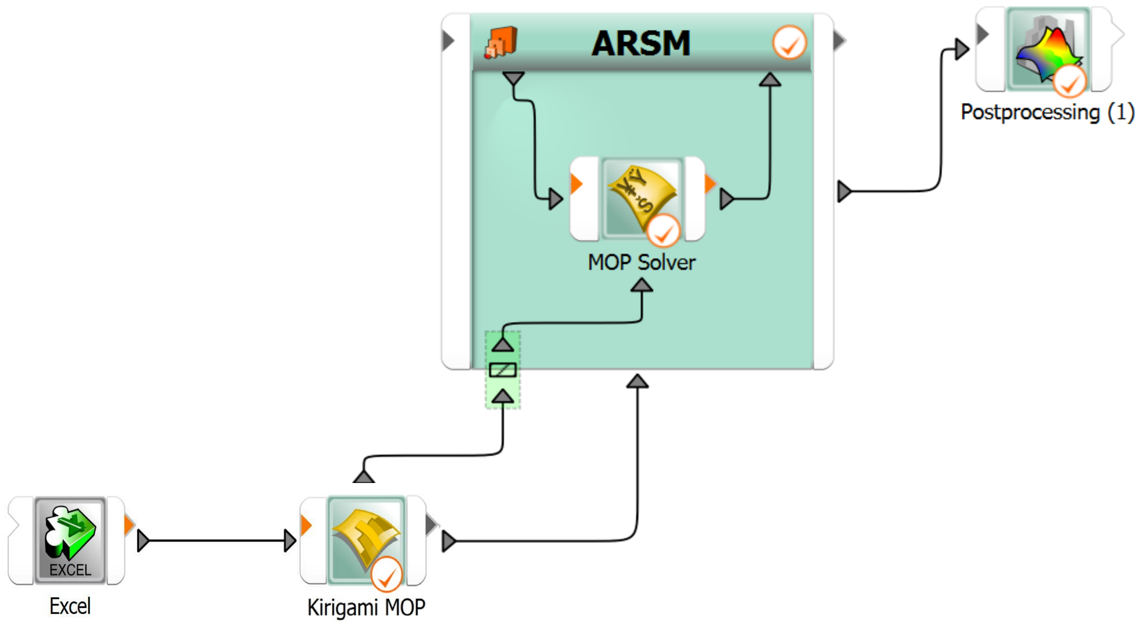
Target Stiffness: 315 to 431 N/mm

H: 8.7mm (for a 10mm interlayer)

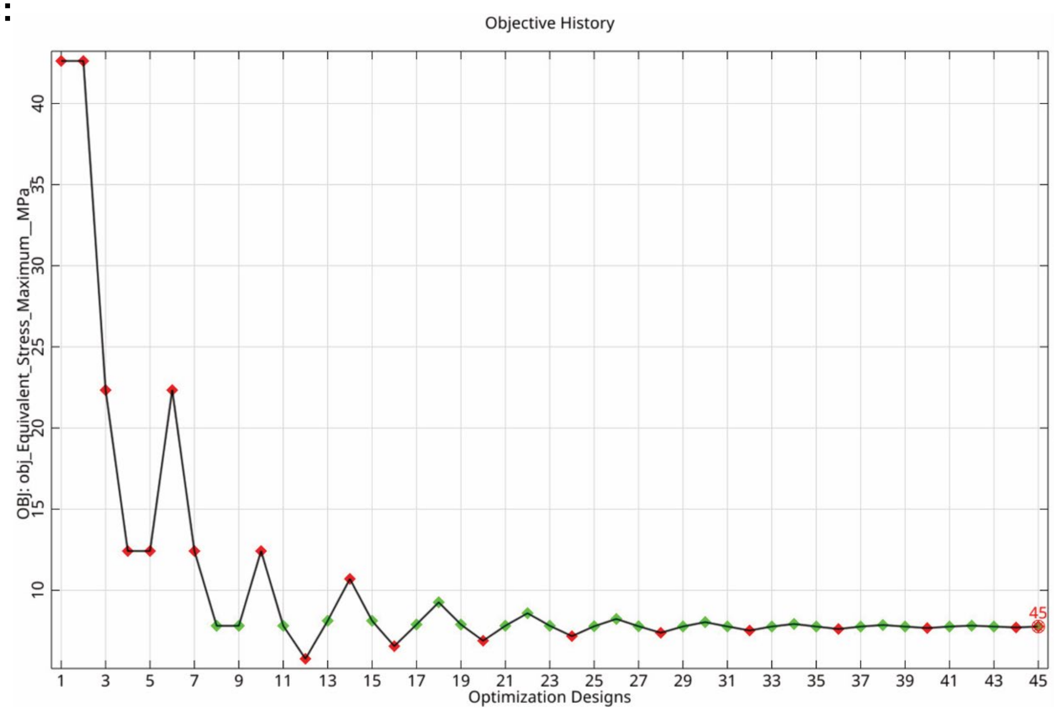
Optimization objectives:

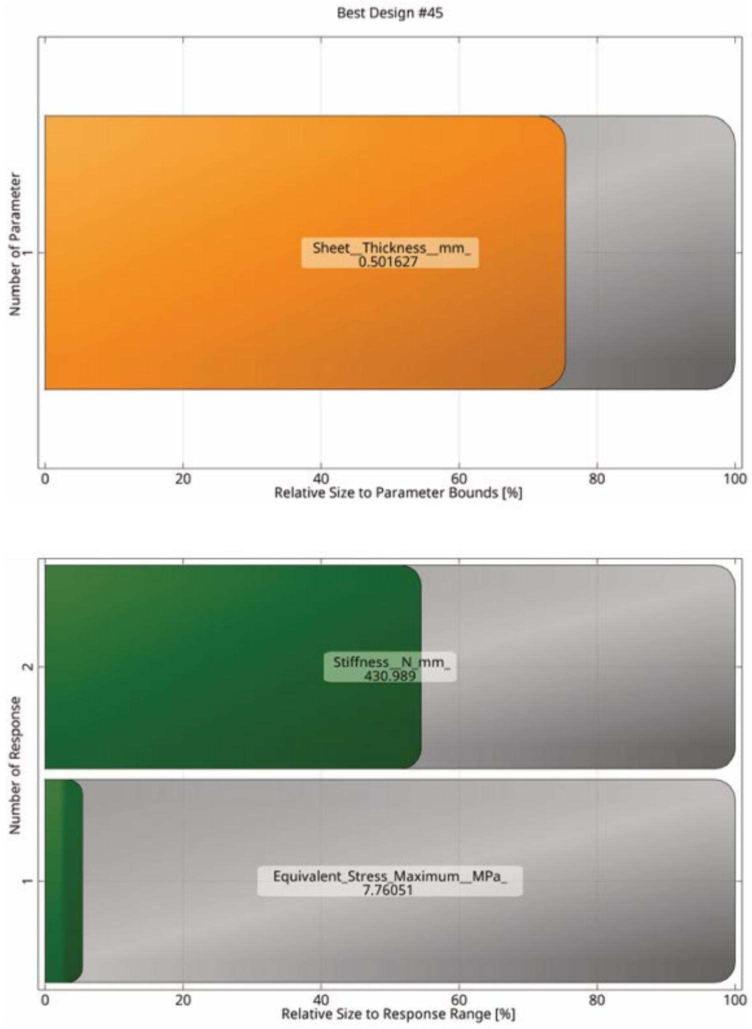
Minimize equivalent stress maximum





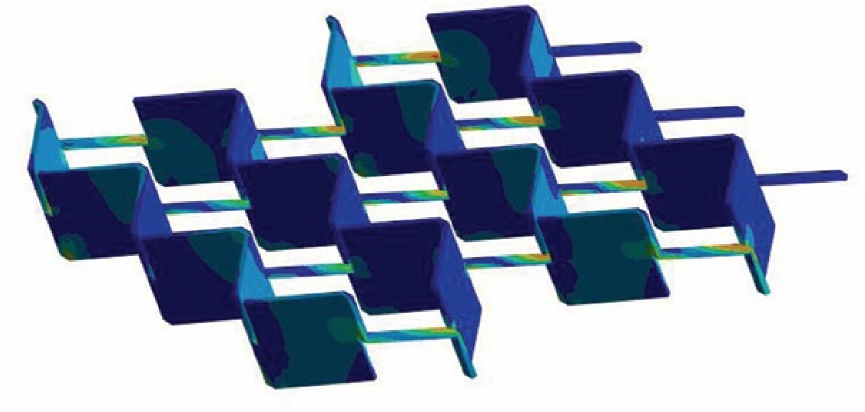
Results:





<u>Optimum sheet thickness: 0.5mm</u>

Validation:

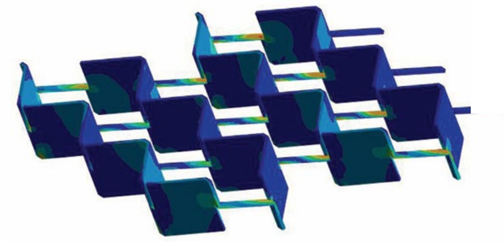


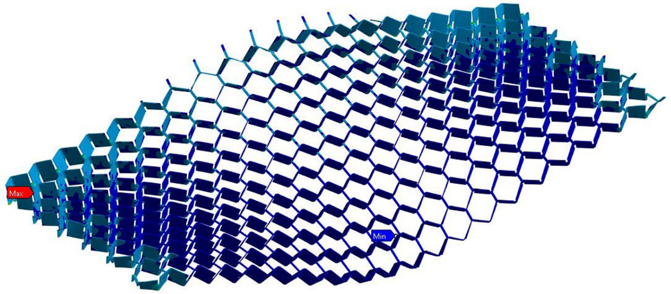
Equivalent stress - uniformity

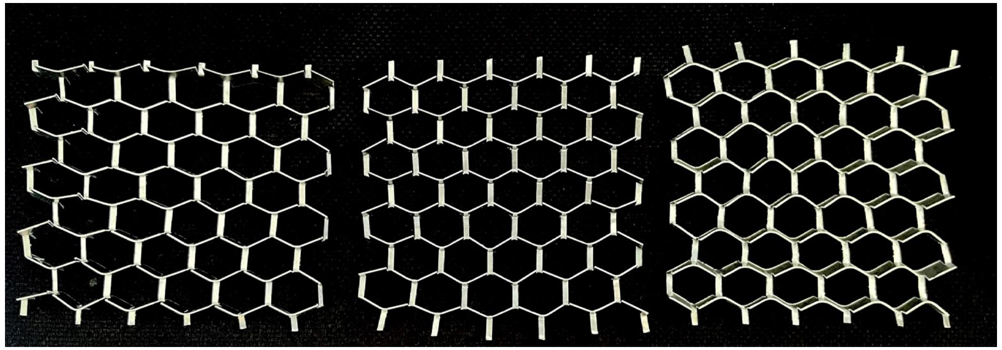
Design Inputs					Responses	
	Sheet Thickness (in mm)	H (in mm)	W (in mm)	L (in mm)	Stiffness (N/mm)	Equivalent Stress Maximum (Mpa)
45					Response Predicted	
	0.501627	8.7	1.2	8.7	430.989	7.76051
					Actual (FEA)	
	0.5	8.7	1.2	8.7	415	8.294

Figure 102: Predicted results vs FEA results on best design

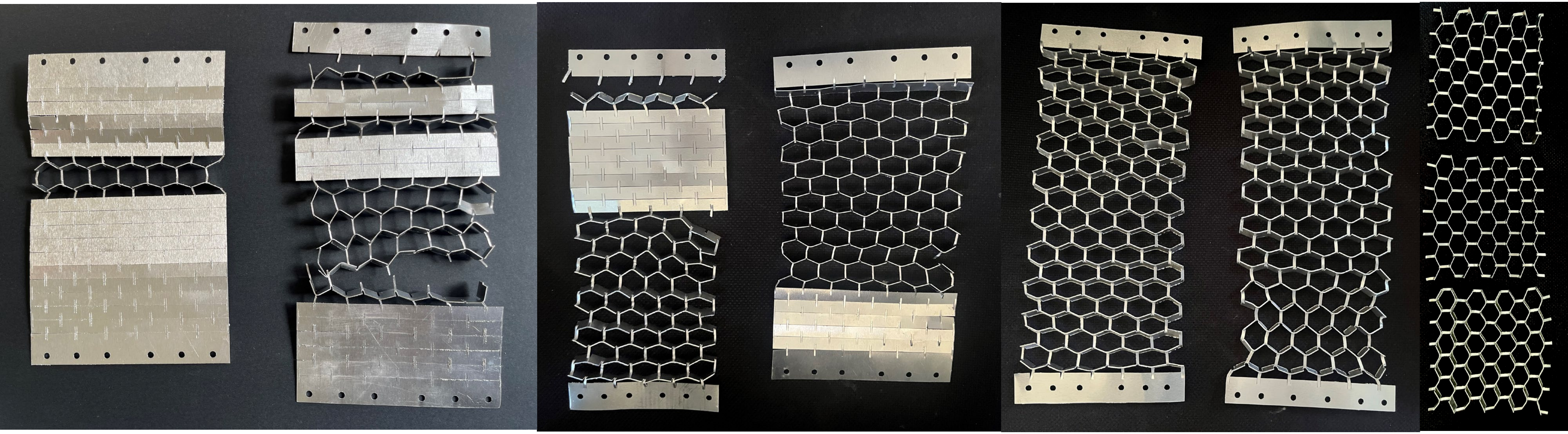
Stiffness Range for the kirigami interlayer: 315 to 431 N/mm



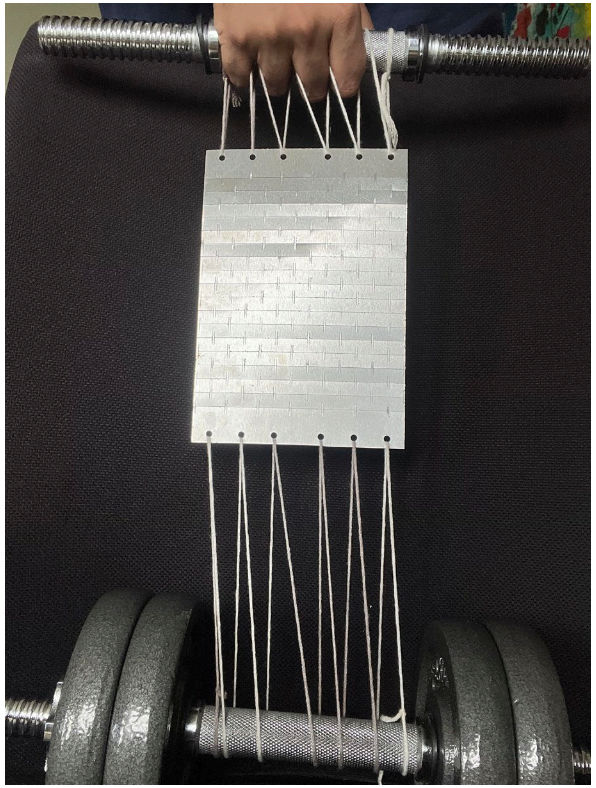


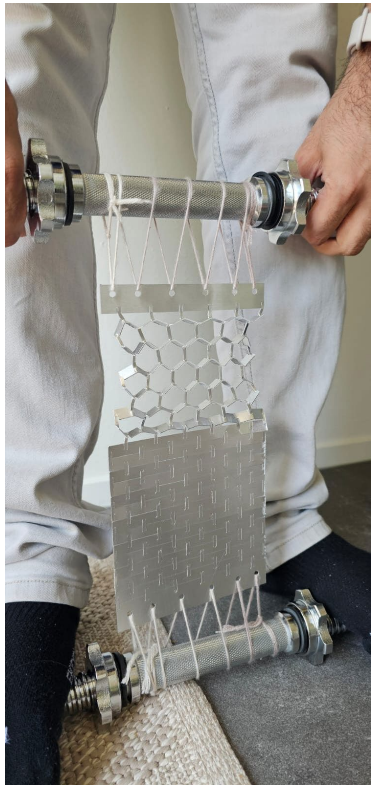


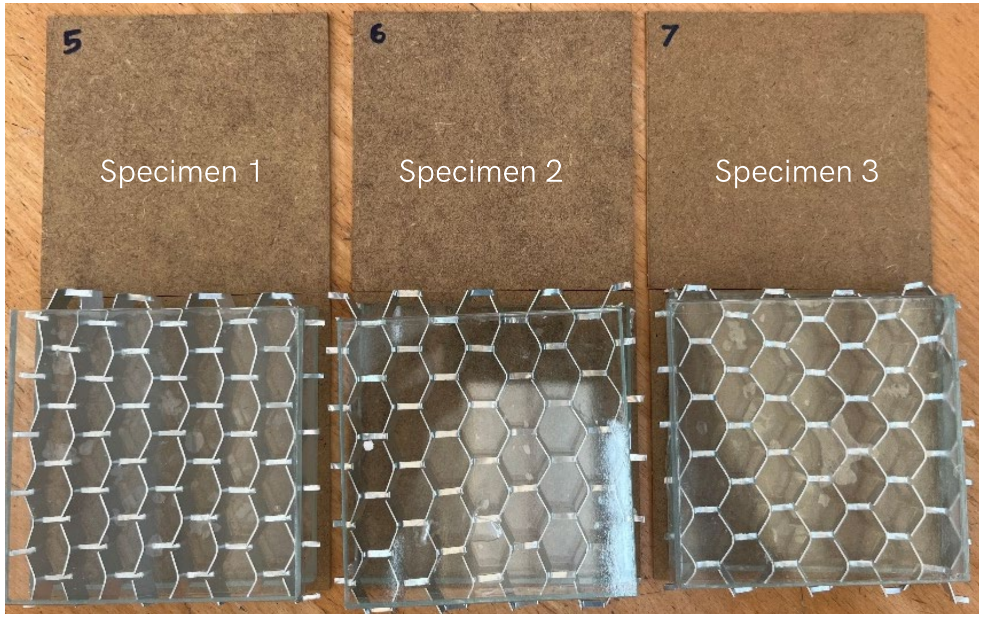
Kirigami prototype Activation



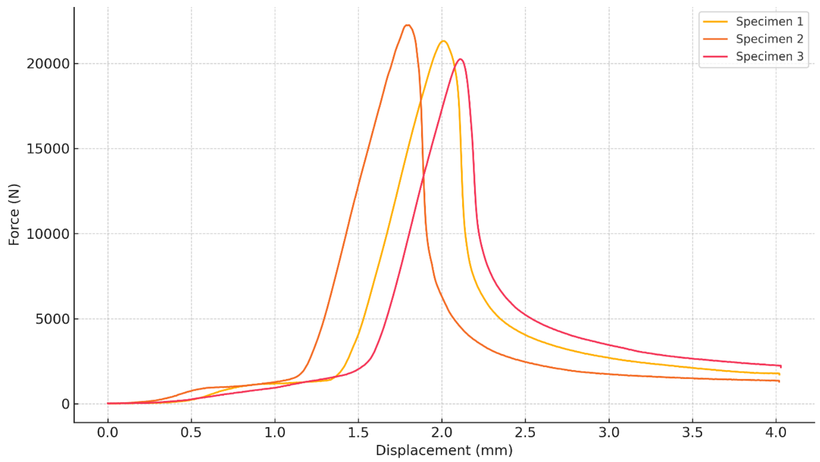
Kirigami prototype Activation

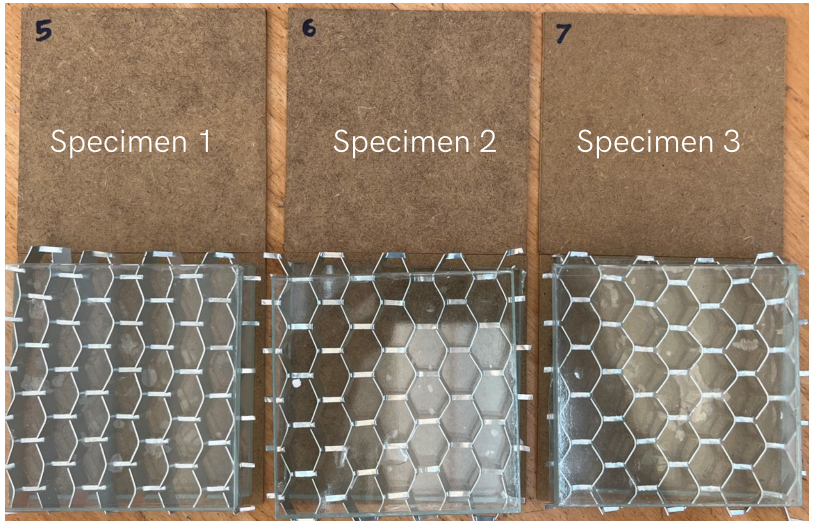


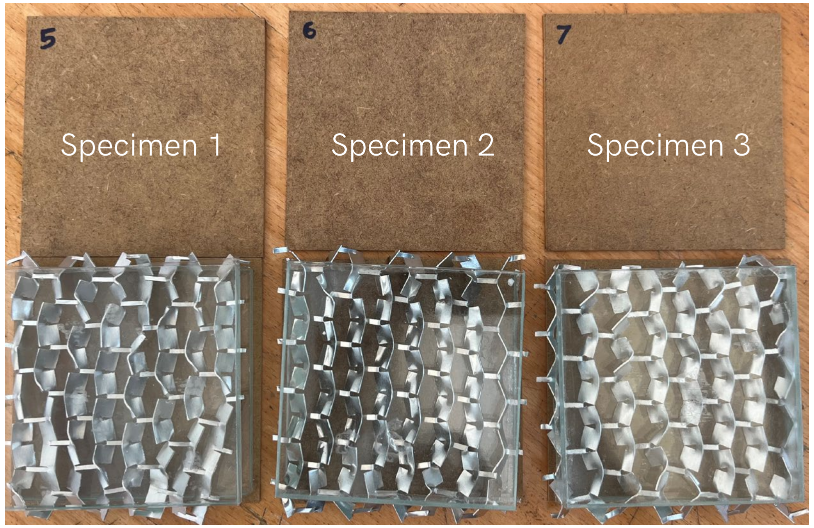


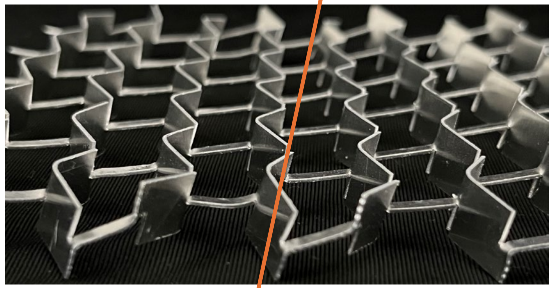


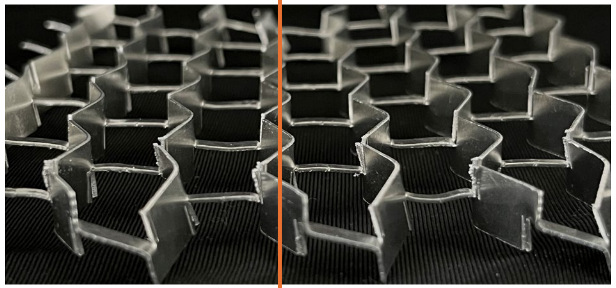
Kirigami sandwich compression test

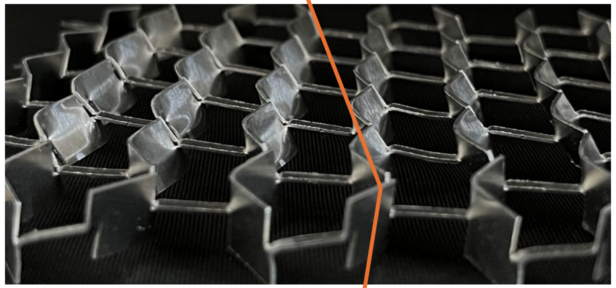


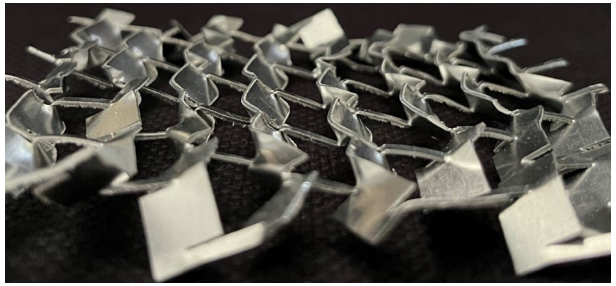












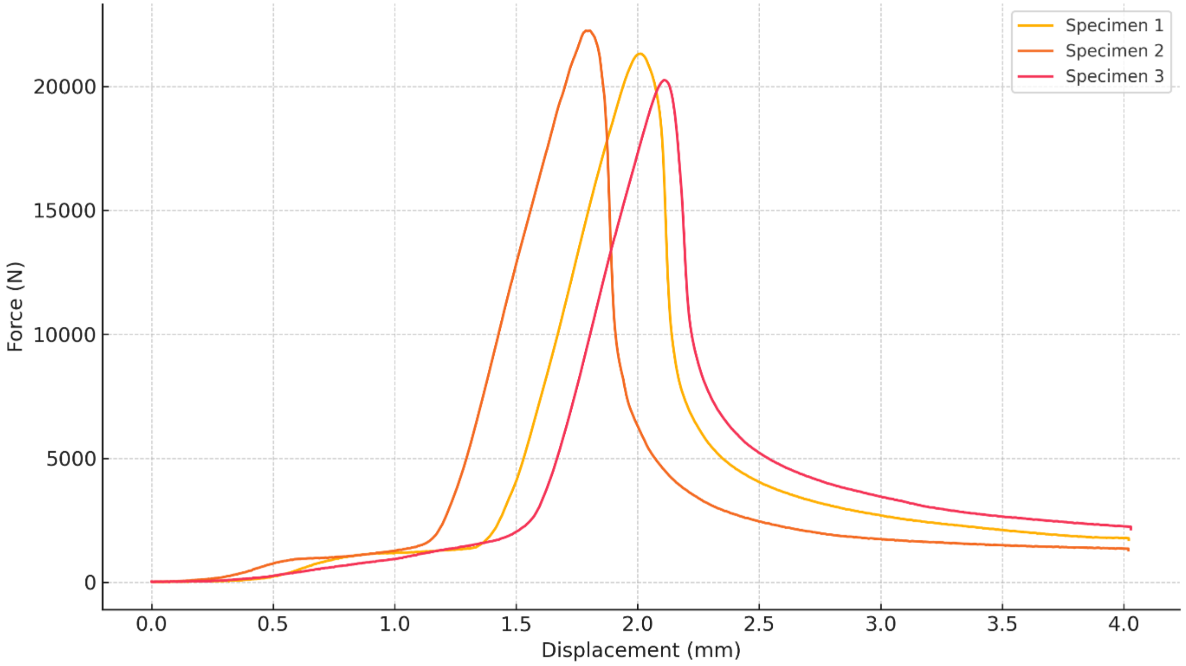
Activated Kirigami

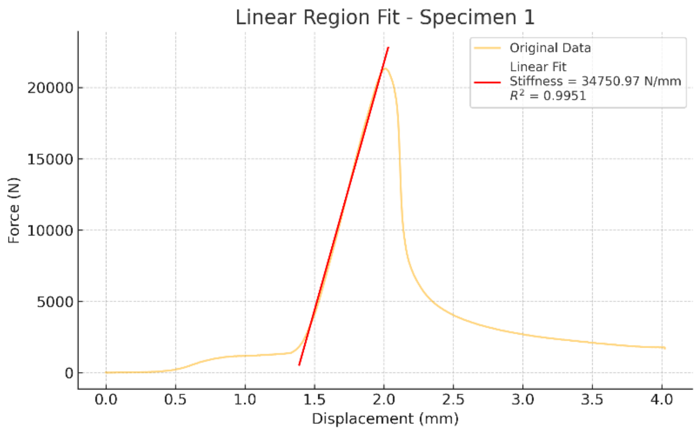
~10kN

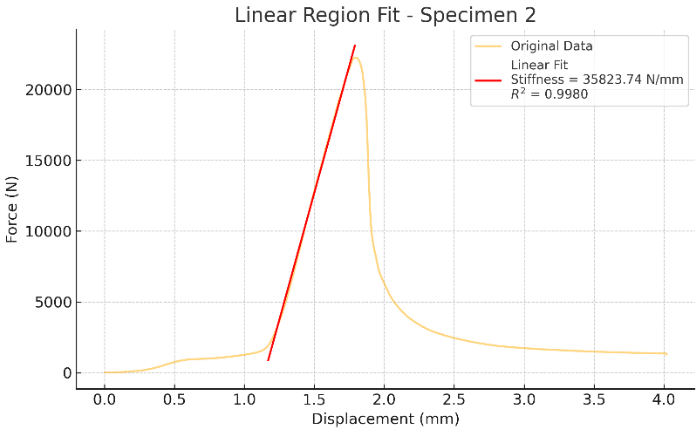
~19kN

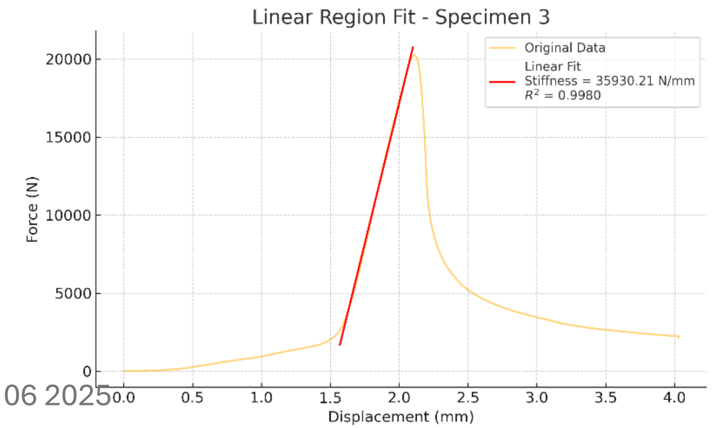
>20kN

Kirigami sandwich compression test

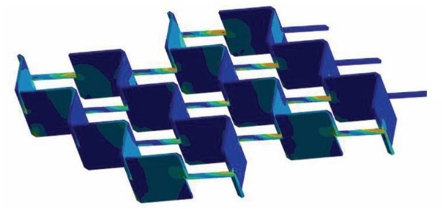

Specimen 1
Specimen 2
Specimen 3
Force (N)
Displacement (mm)

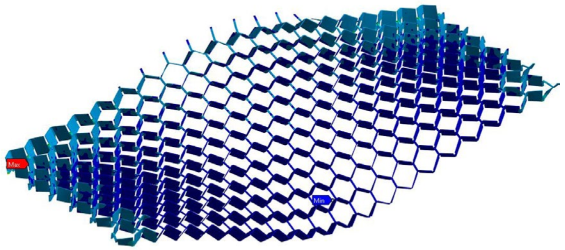

Linear Region Fit - Specimen 1
Original Data
Linear Fit
Stiffness = 34750.97 N/mm
R^2 = 0.9951
Force (N)
Displacement (mm)


Linear Region Fit - Specimen 2
Original Data
Linear Fit
Stiffness = 35823.74 N/mm
R^2 = 0.9980
Force (N)
Displacement (mm)


Linear Region Fit - Specimen 3
Original Data
Linear Fit
Stiffness = 35930.21 N/mm
R^2 = 0.9980
Force (N)
Displacement (mm)

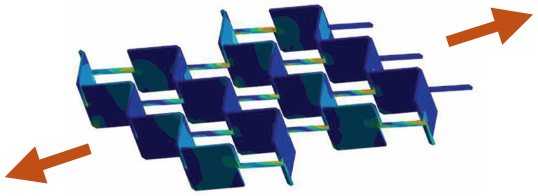
Reflection:



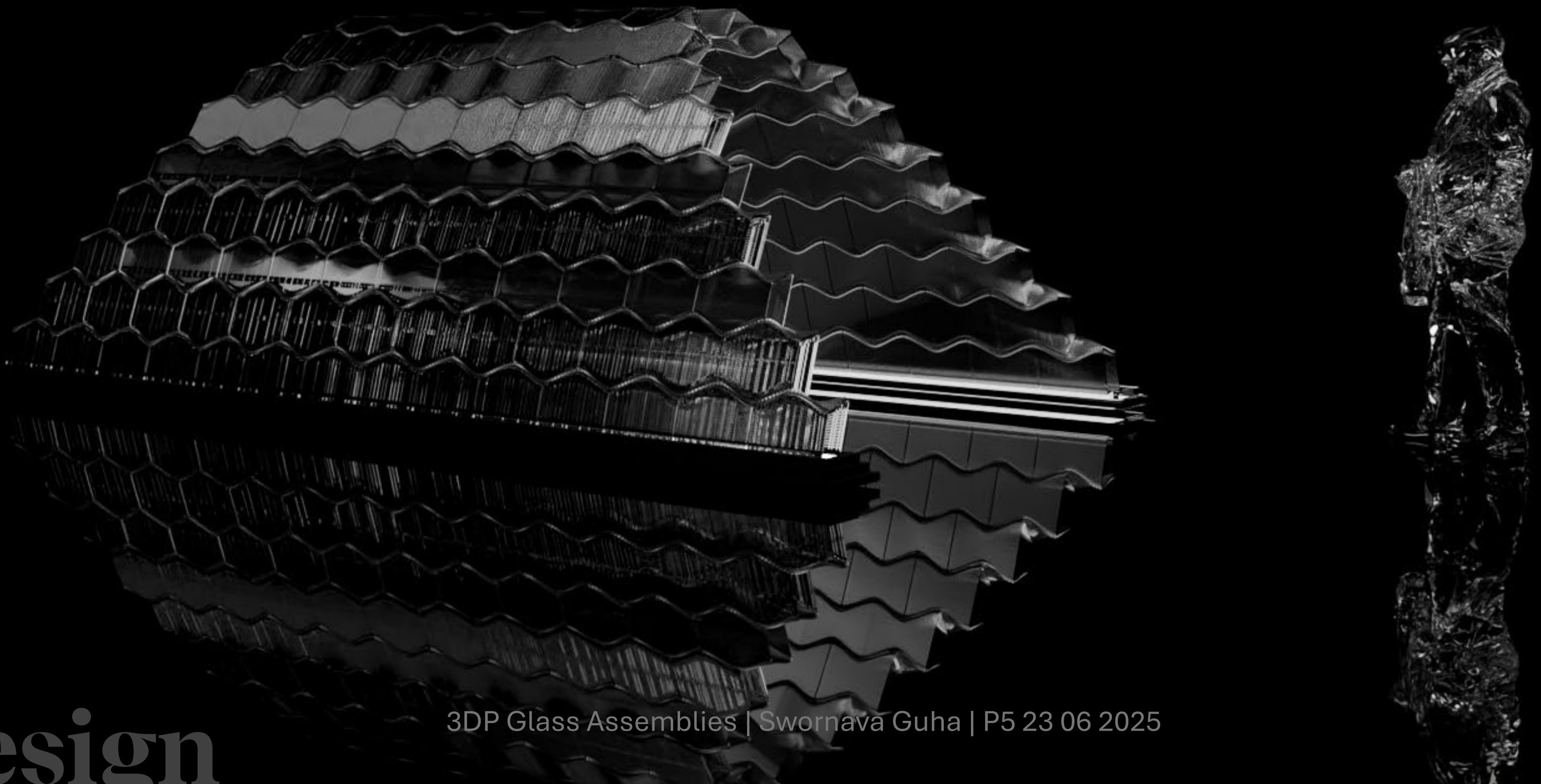


- The **activated kirigami structure is complex** depending on many factors. It **cannot be simply parametrized in a model**
- Surrogate **model does not predict real-world conditions.**
- The kirigami's **response on a 3DP osteomorphic surface is still unknown** due to lack of a strategy for simulation.

Suggestion:

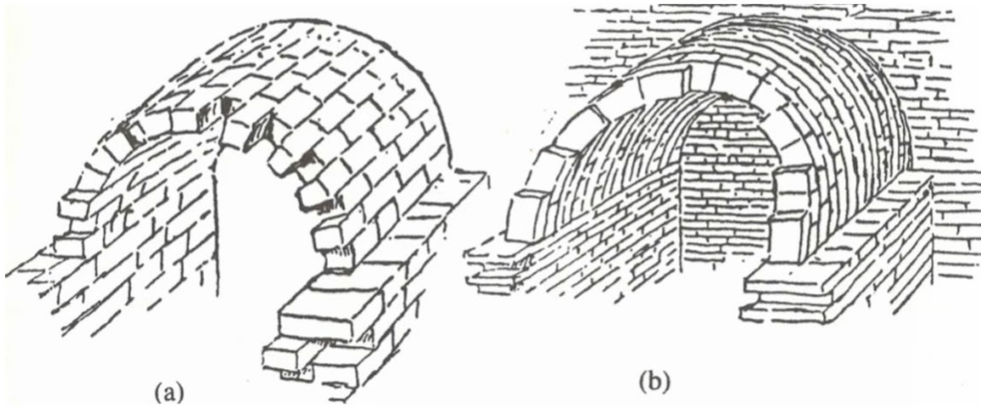


- **Simulate the kirigami activation in Ansys** to fine tune the Surrogate
- The Parametric model needs to be fine tuned OR Surrogate model needs to be created with **experimental data**
- **Experimentally evaluate** the response of kirigami on a 3DP surface and on an osteomorphic surface.

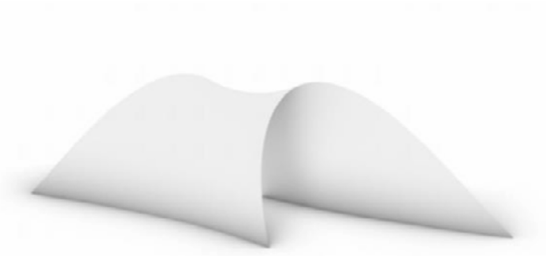


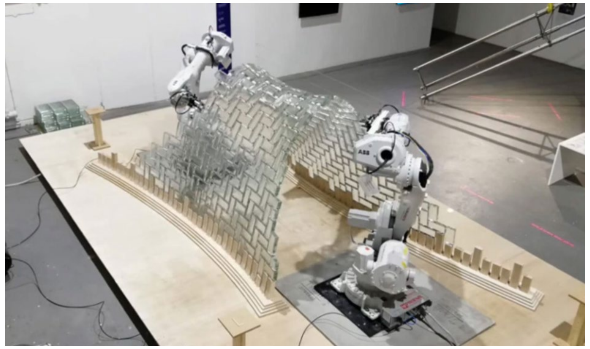
Final Design

Inspiration



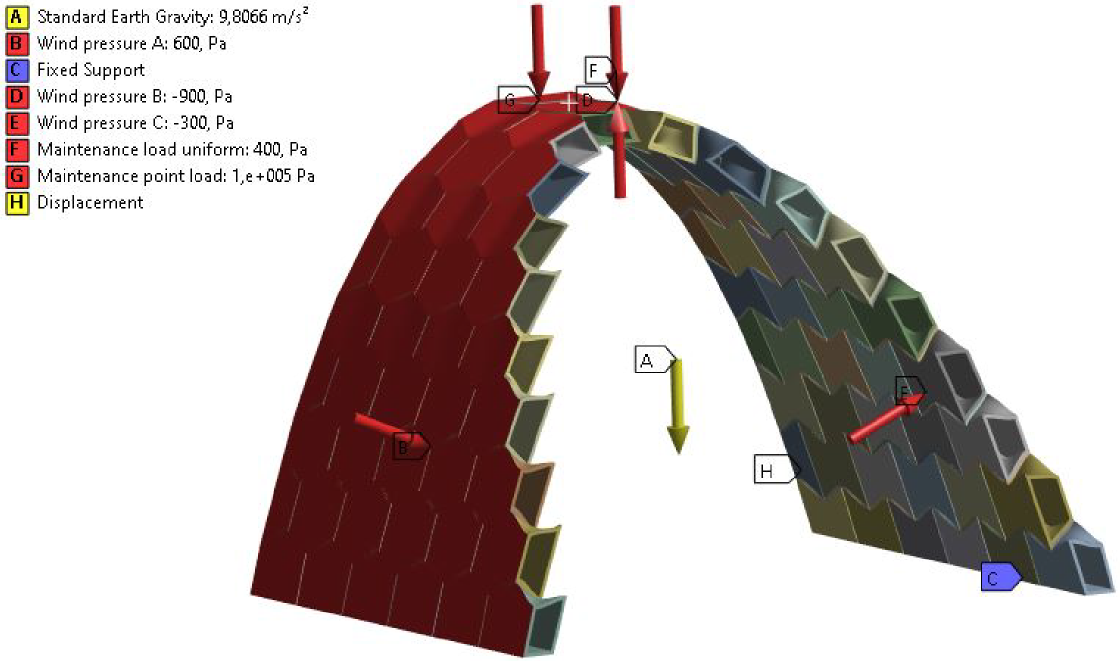
Barrel Vault Techniques (Source: Heymann, 1995)



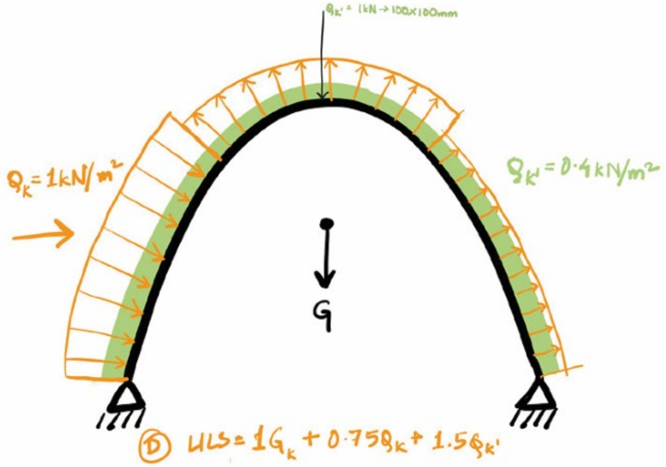


Glass Vault, Princeton University (Beghini et al., 2020)

Boundary conditions

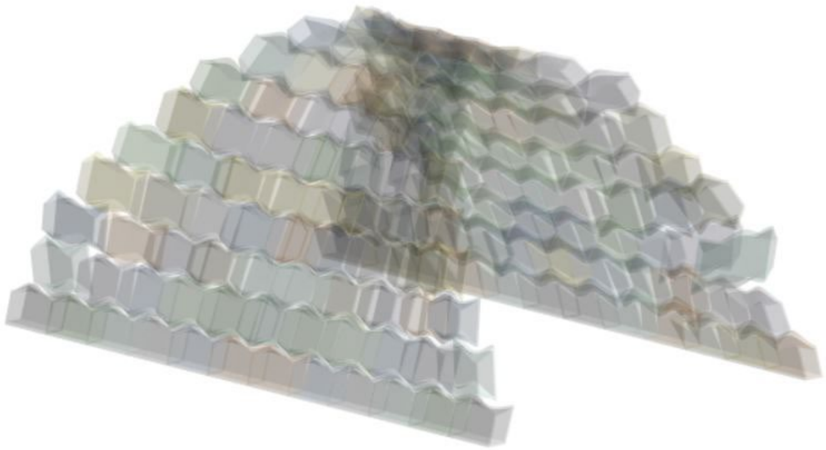


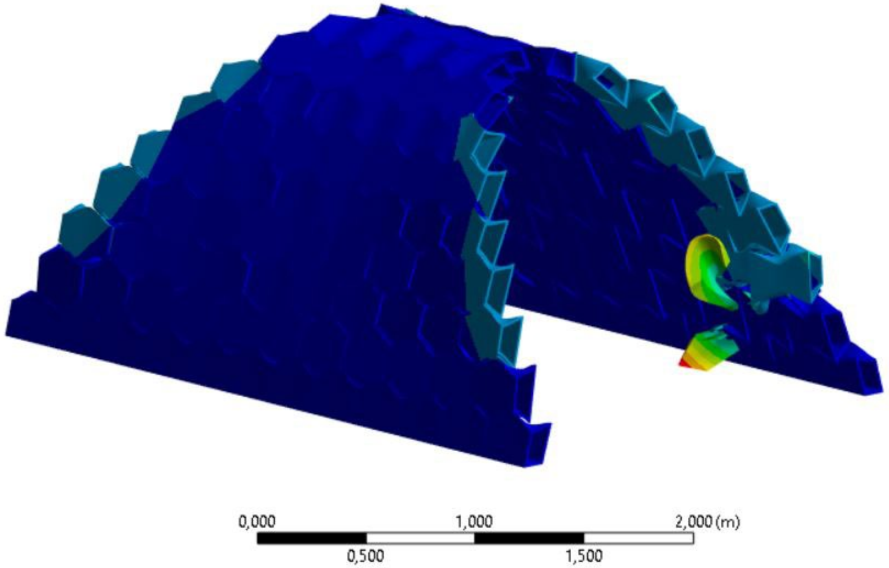
Loads



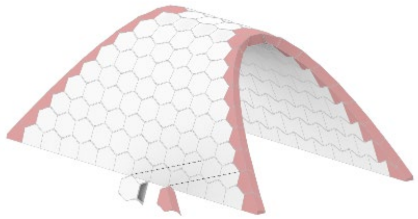
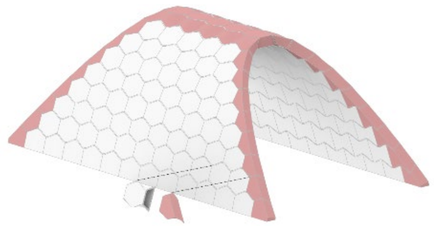
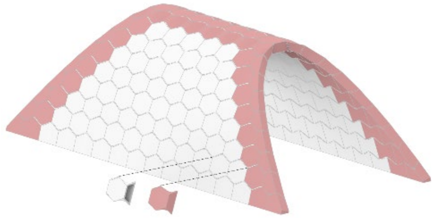
- **Self weight**
- **Pressures on vaulted roofs due to wind** as per Eurocode 1991-1-0
- **A maintenance load** as per Eurocode 1991-1-1, Dutch National Annex: uniform load of 0.4kN/sqm on overall shell, and a point load of 1kN applied on 100x100mm at the centre of the vault

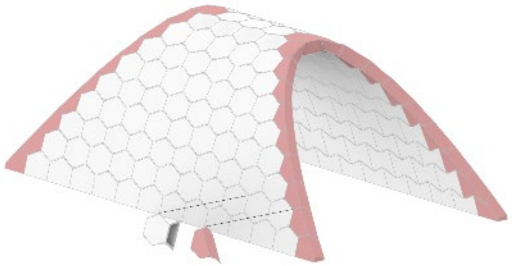
Results

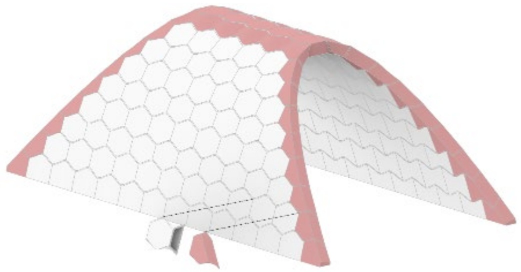


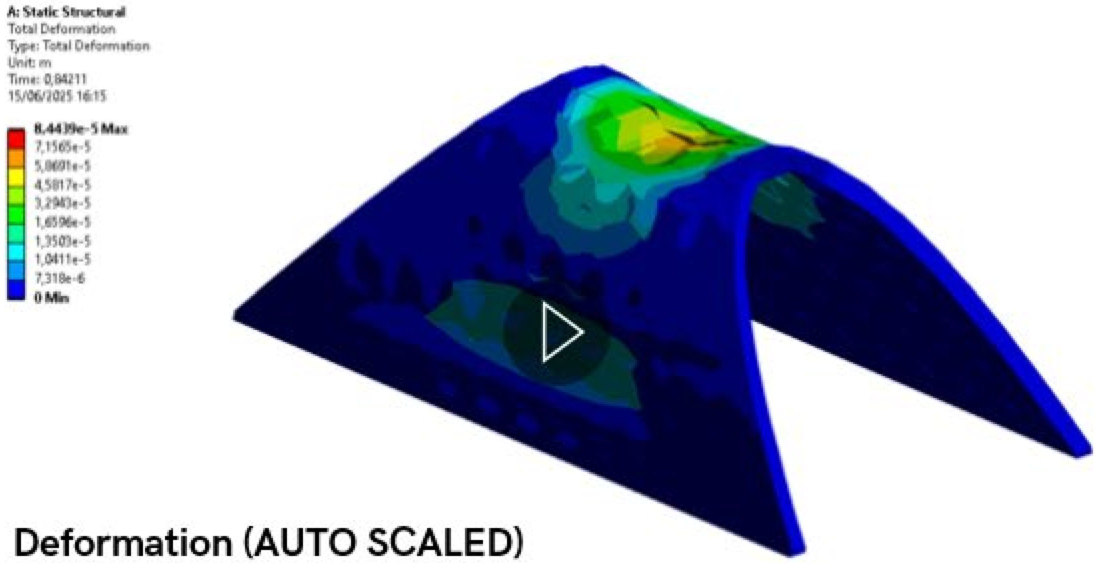


- Stepped free edges are **not completely interlocked**
- **Vault weight** is less for interlock

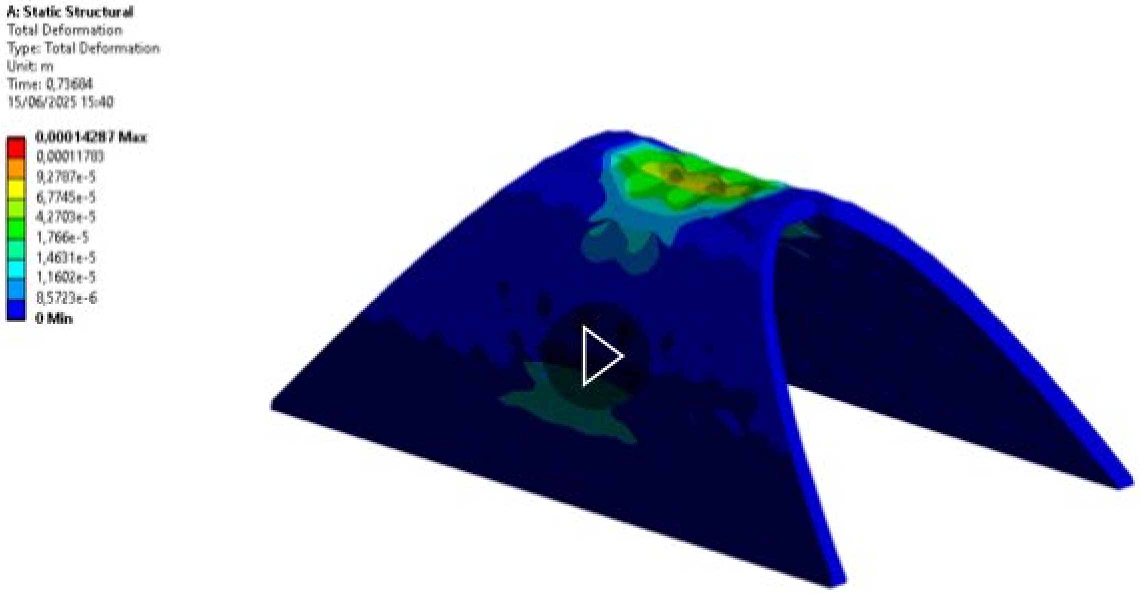
Design Strategy		Maximum Total Deformation (mm)	Maximum tensile stress in glass (MPa)
	Units added at the free edge- made from cast glass and restrained in x, y, and z directions	0.09	7.8
	Units added at the free edge- made from cast glass and restrained in x, y, and z directions + three rows at the top including the keystones considered as cast glass units	0.15	5.6
	2 rows of free edge units made from cast glass and restrained in x, y, and z directions and three rows of units at the top considered as cast glass units for added mass	-	-

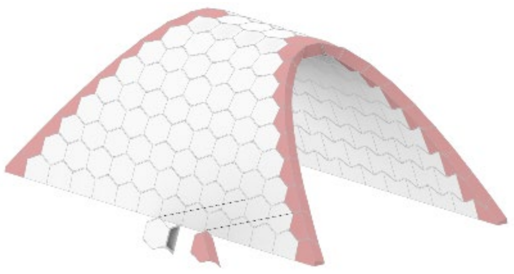


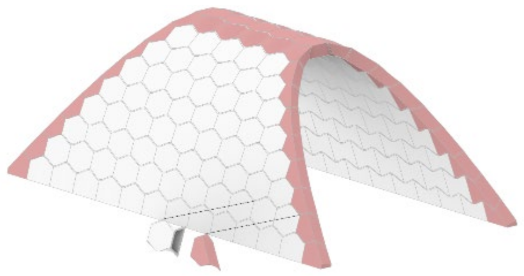


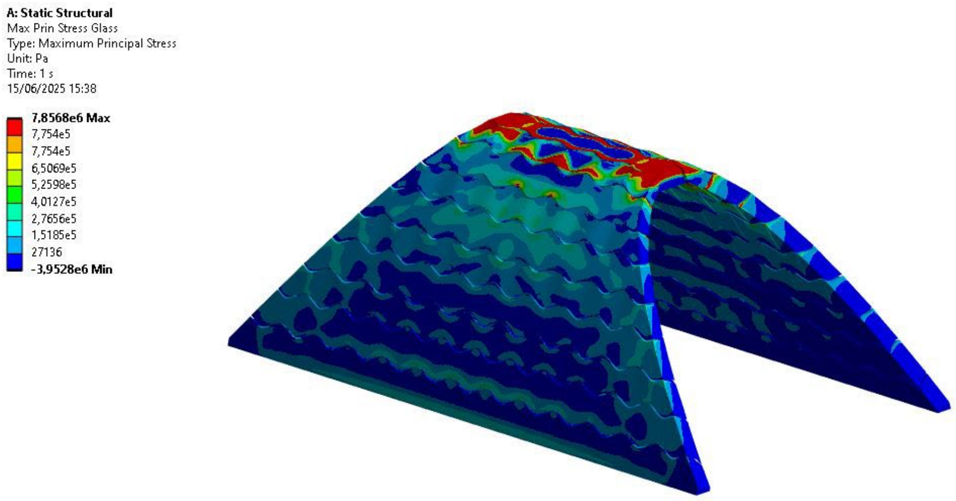


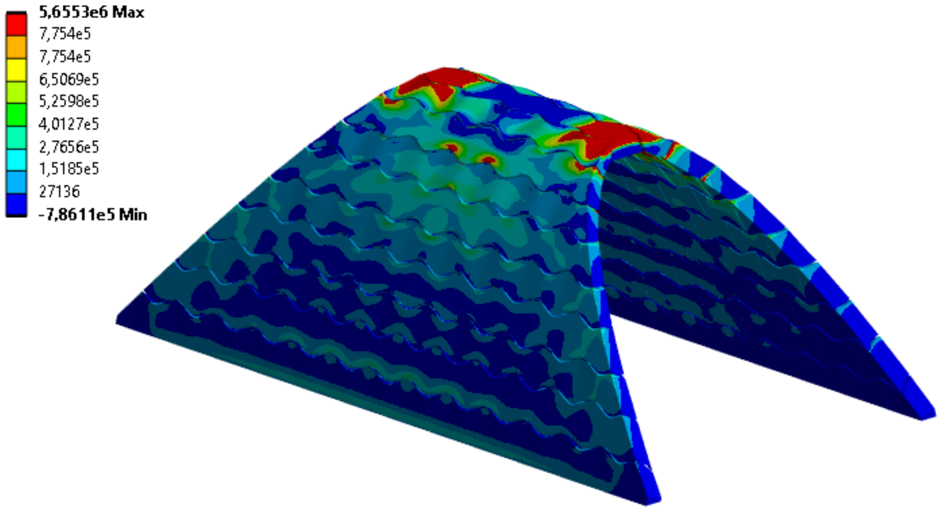
Deformation (AUTO SCALED)



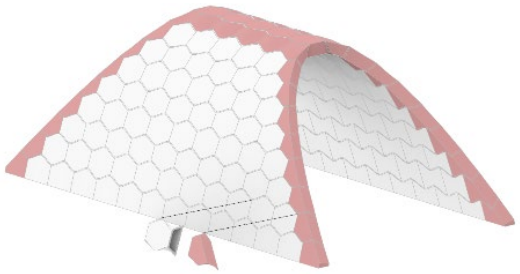




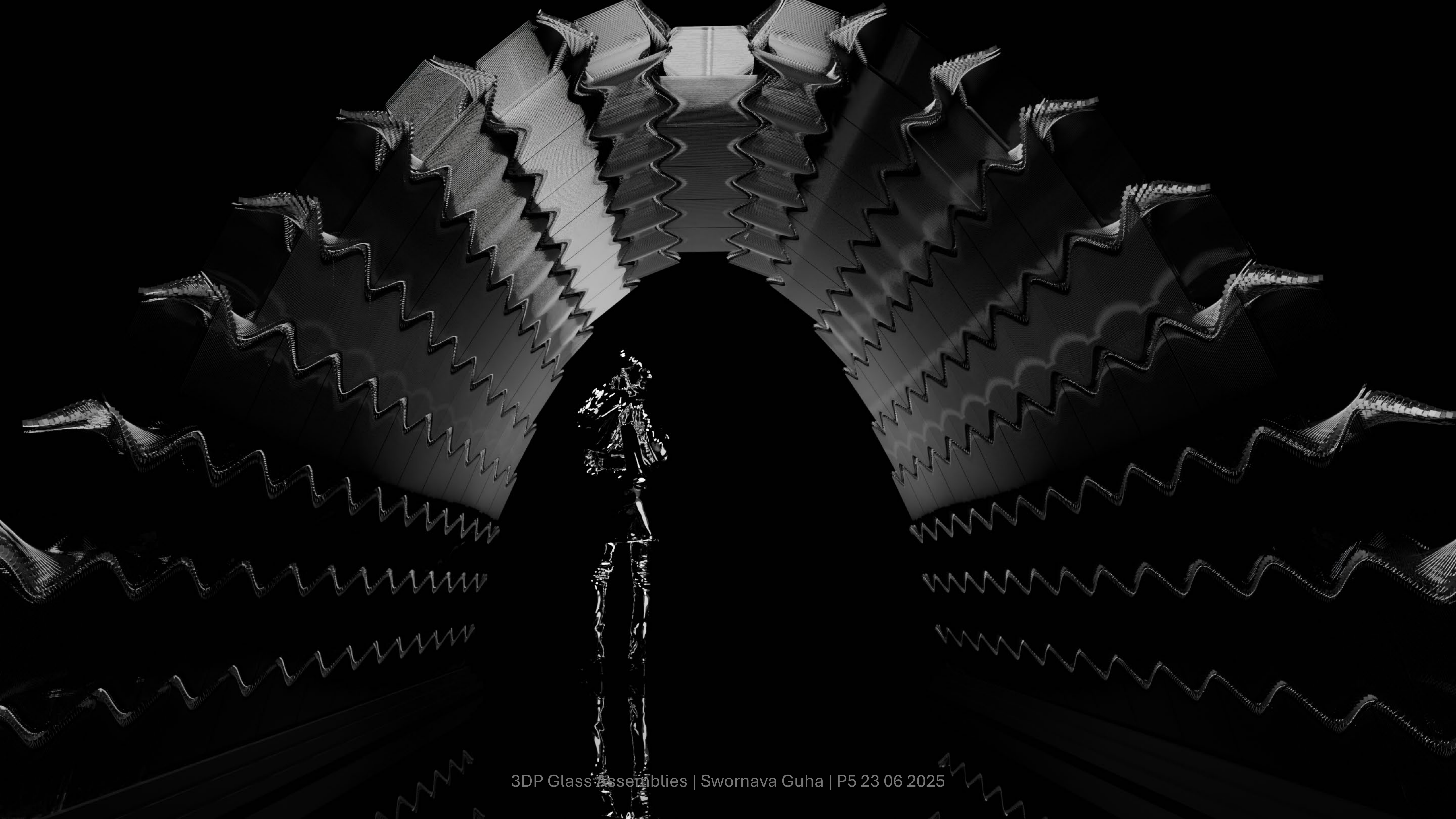


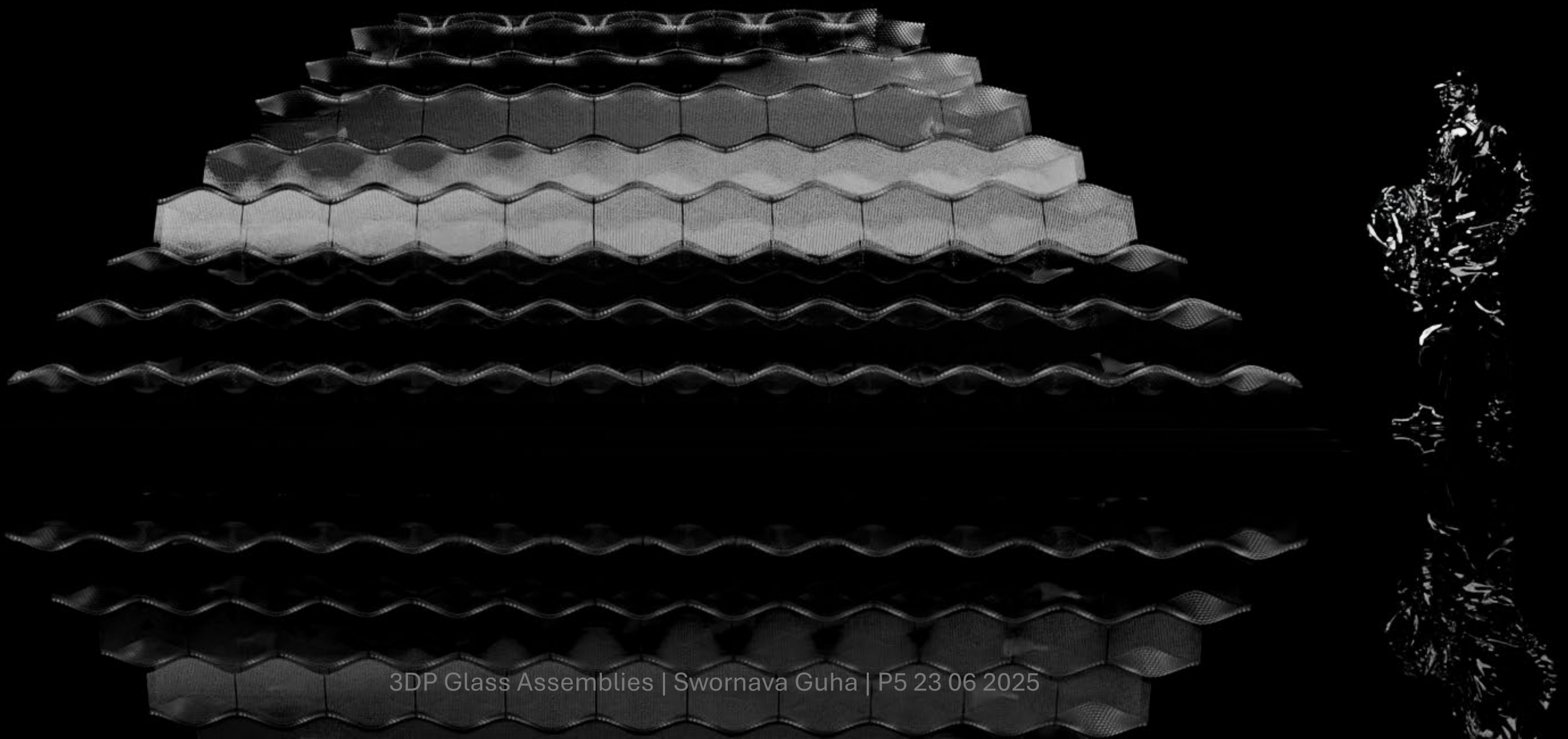


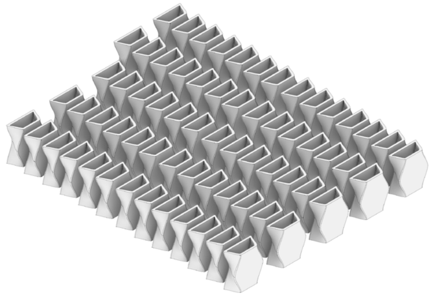
Max. tensile stress in glass **7.8MPa** **5.6MPa**



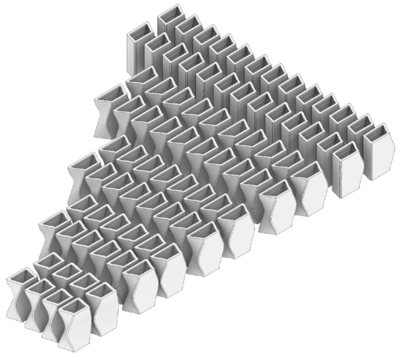
- A heavier structure leads to a better interlocking behavior
- Free edges Need to be restrained for interlocking vault assemblies under eccentric loading



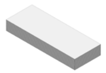




Standard blocks

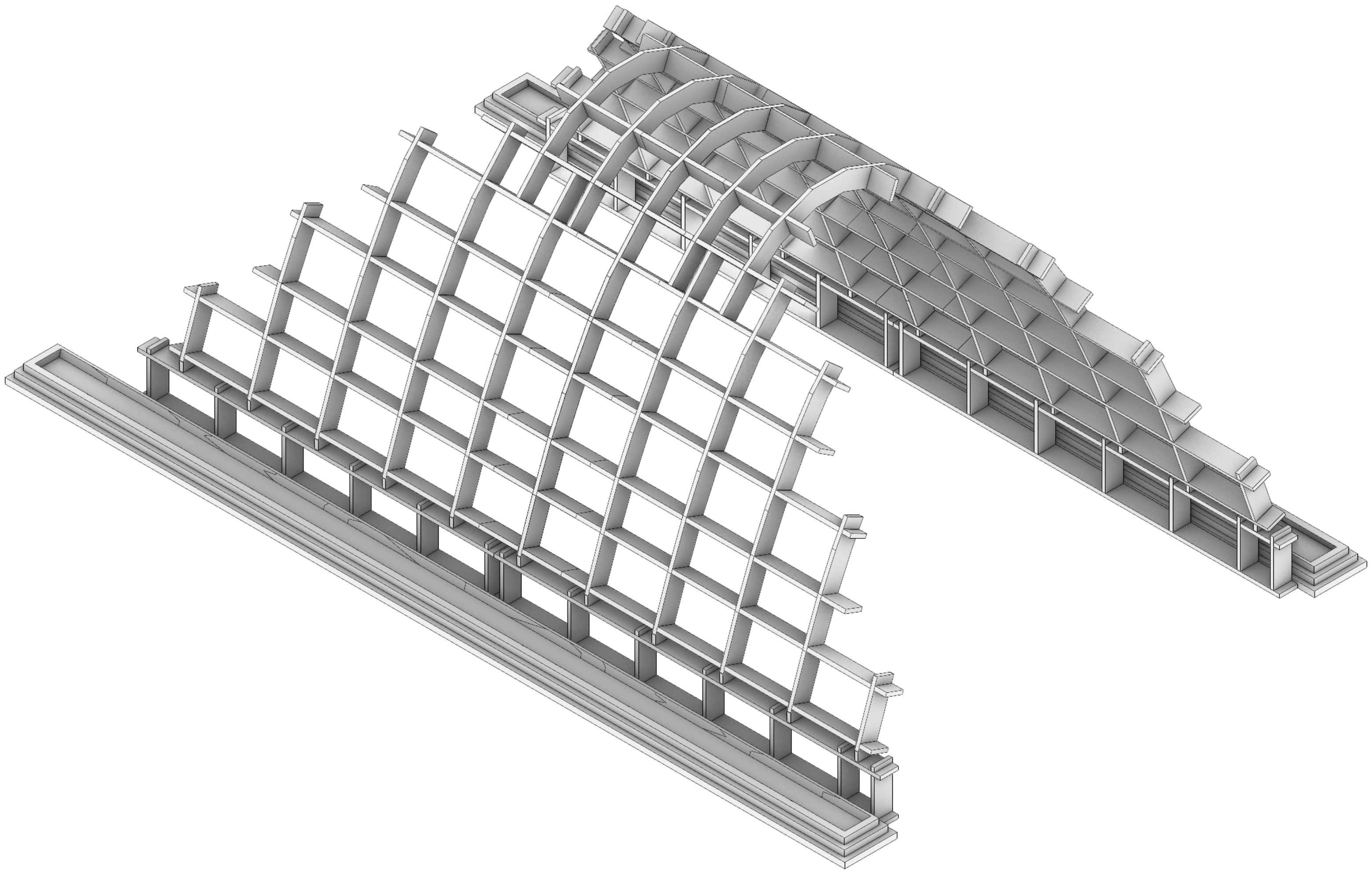


Angular blocks

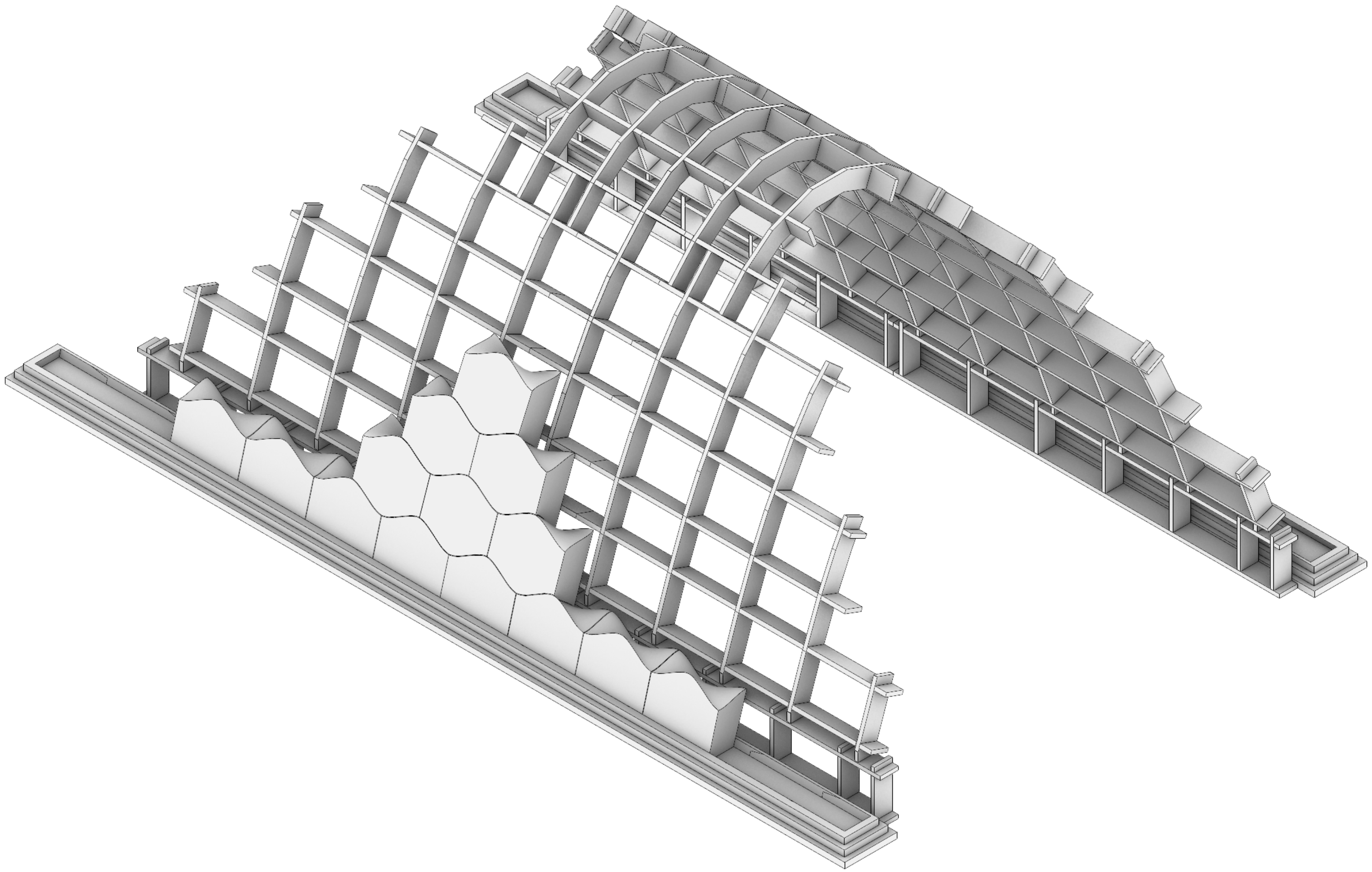


Interlayer

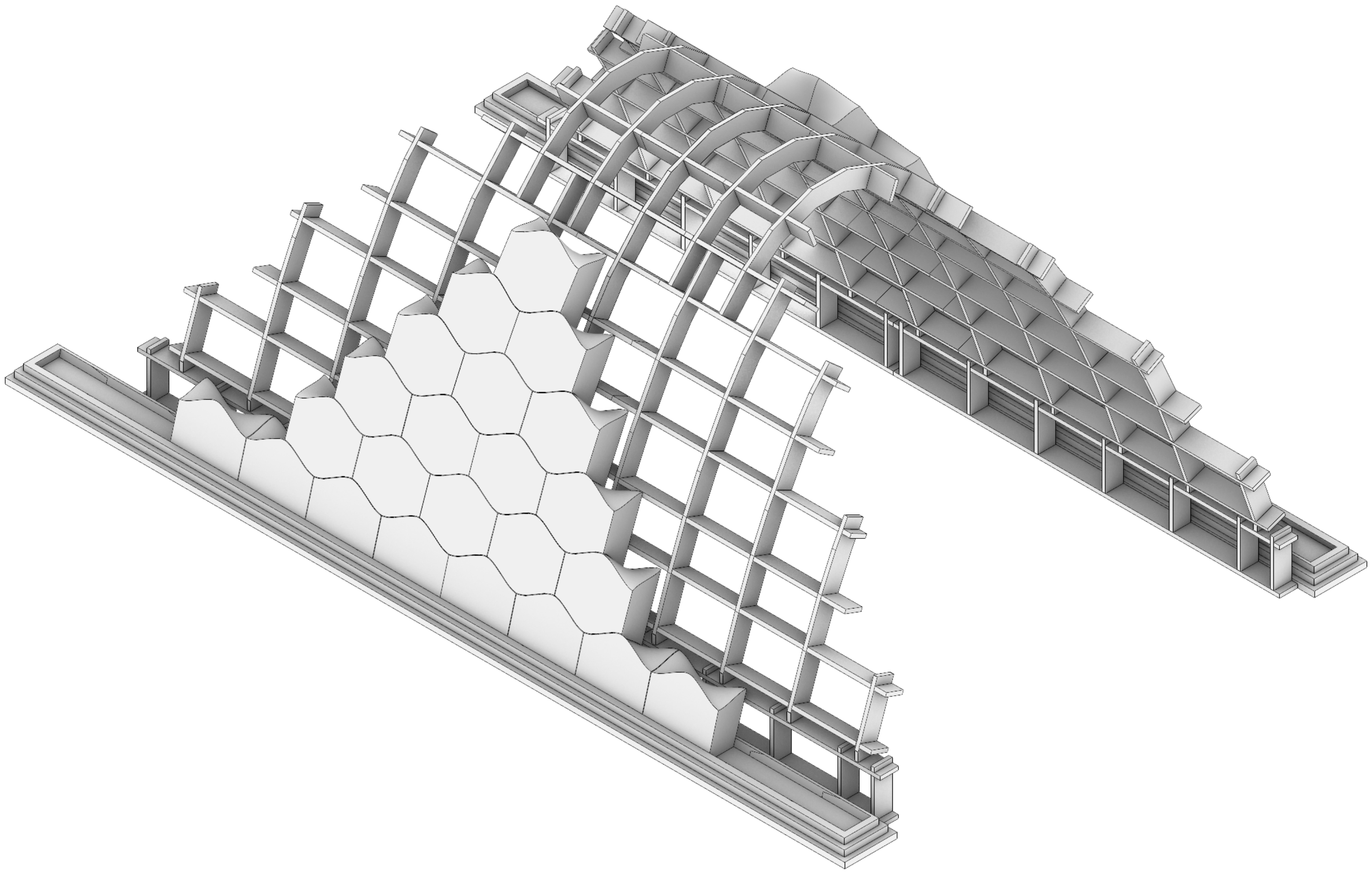
Assembly



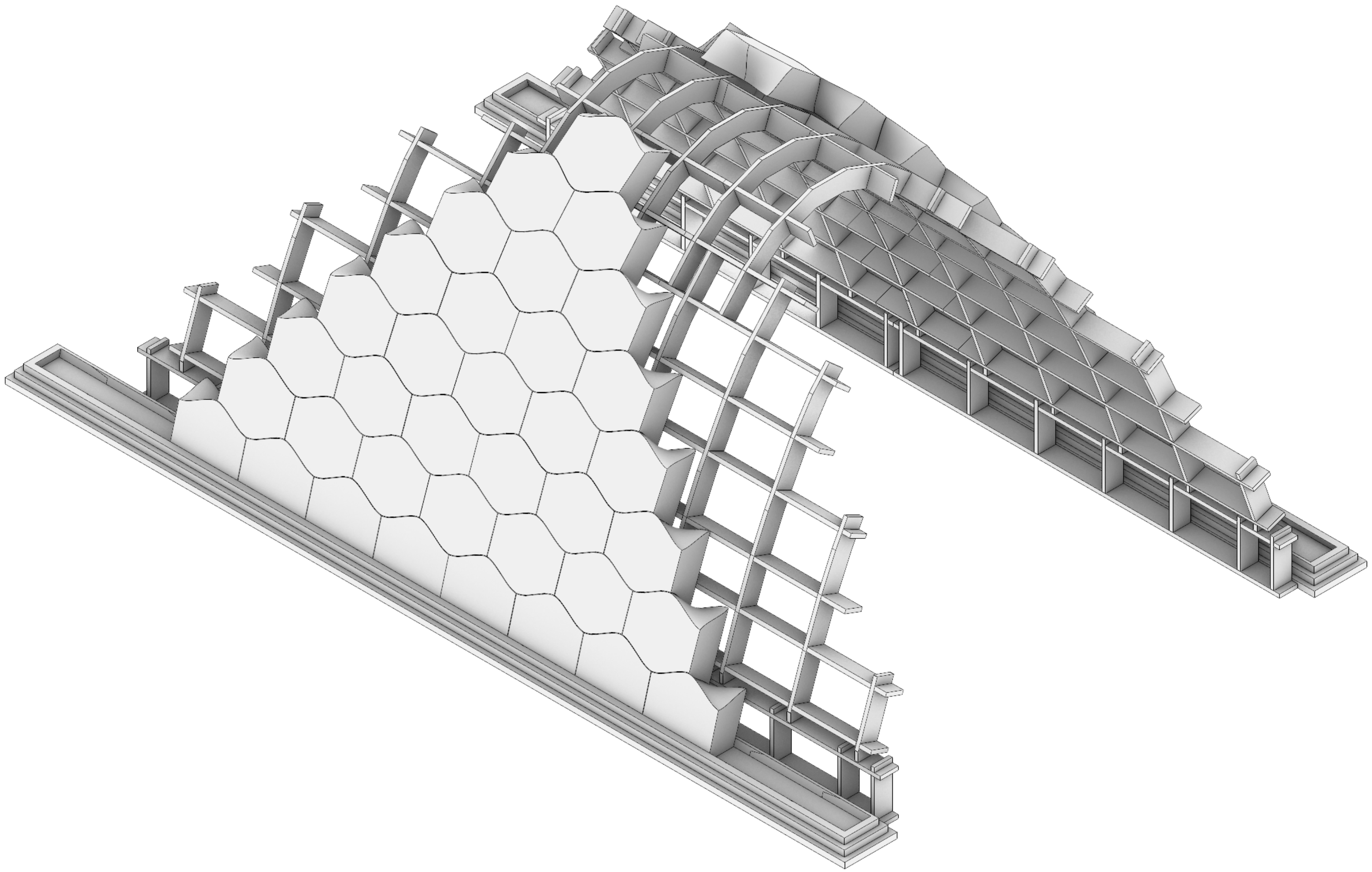
Assembly



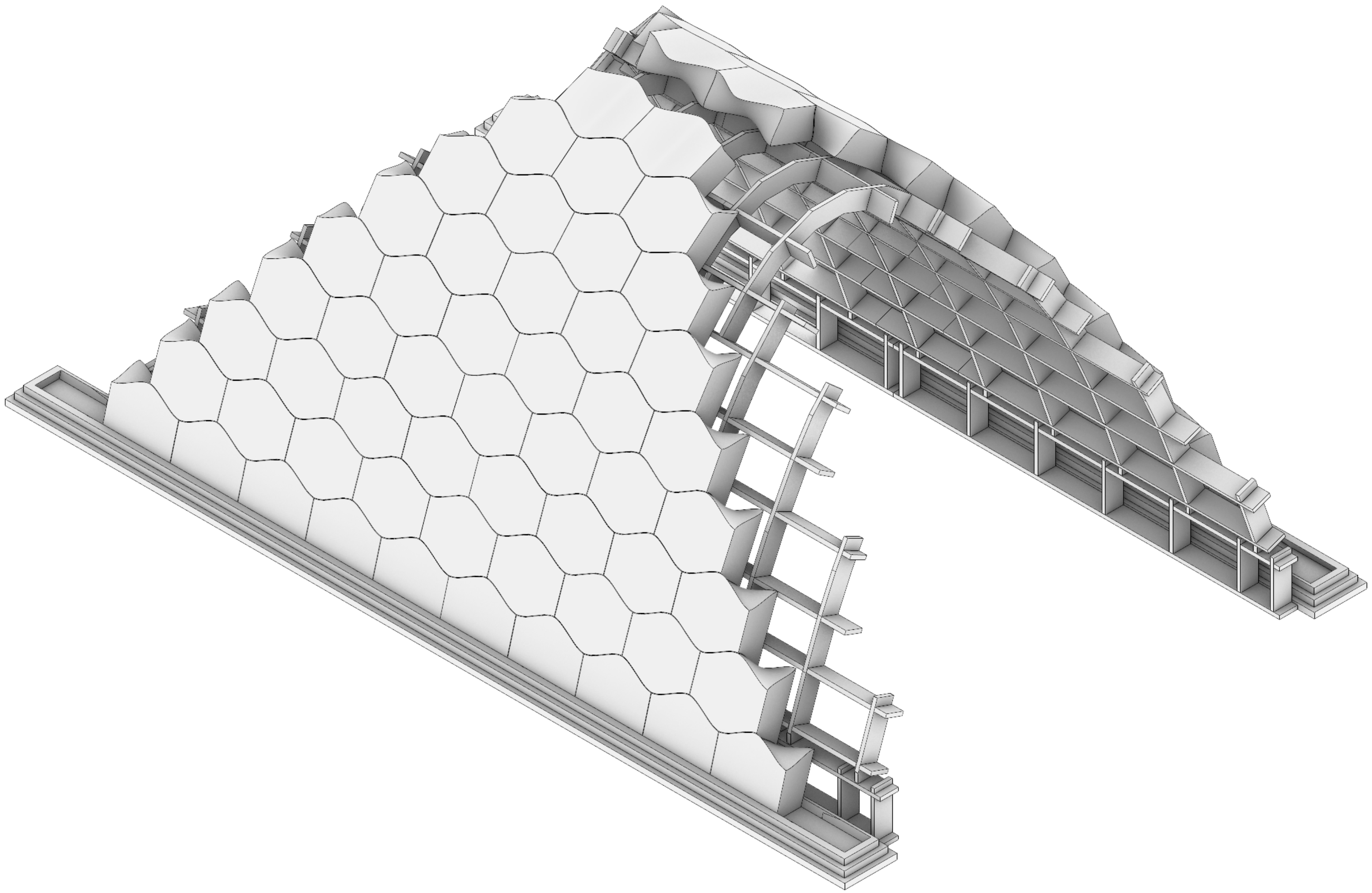
Assembly



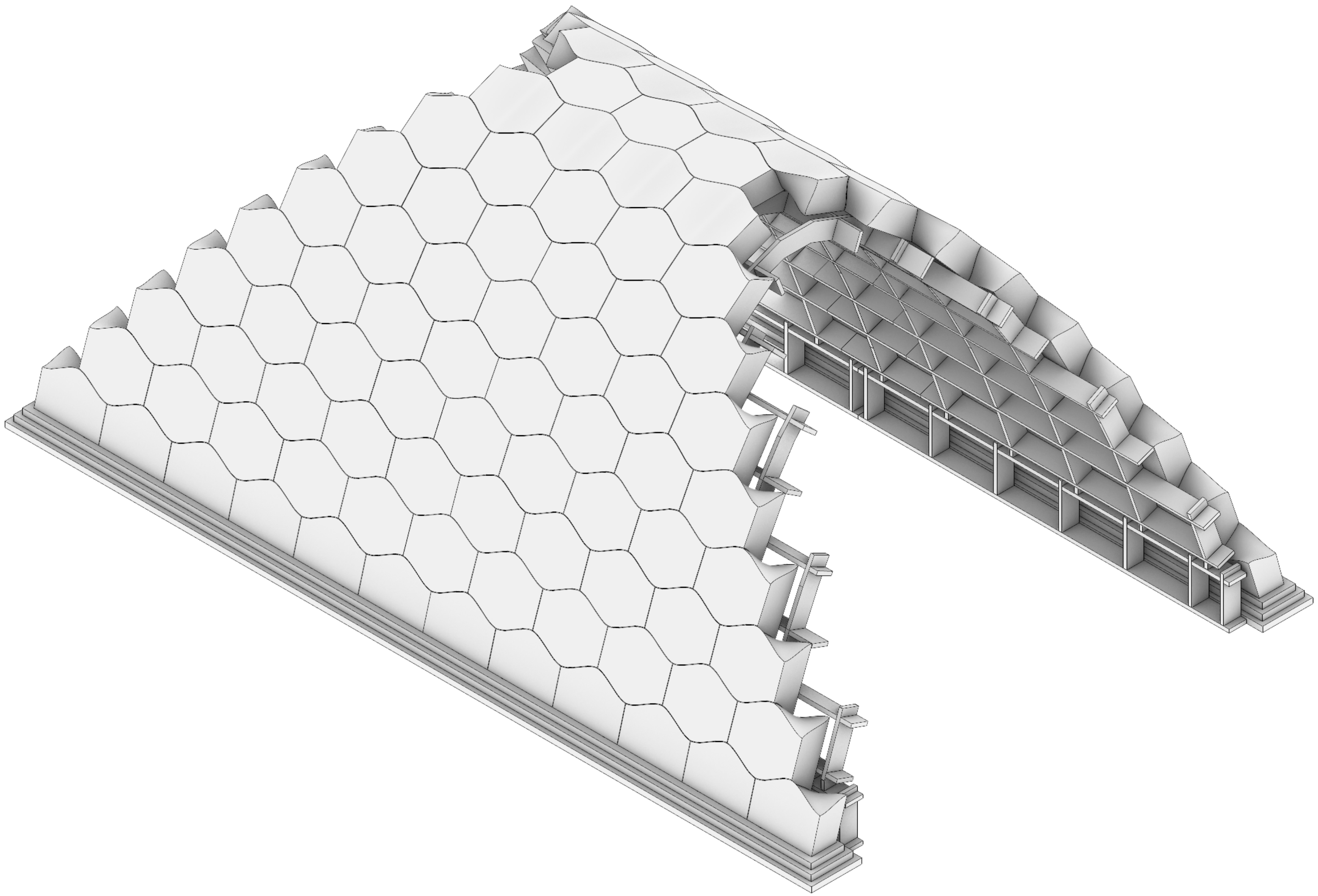
Assembly



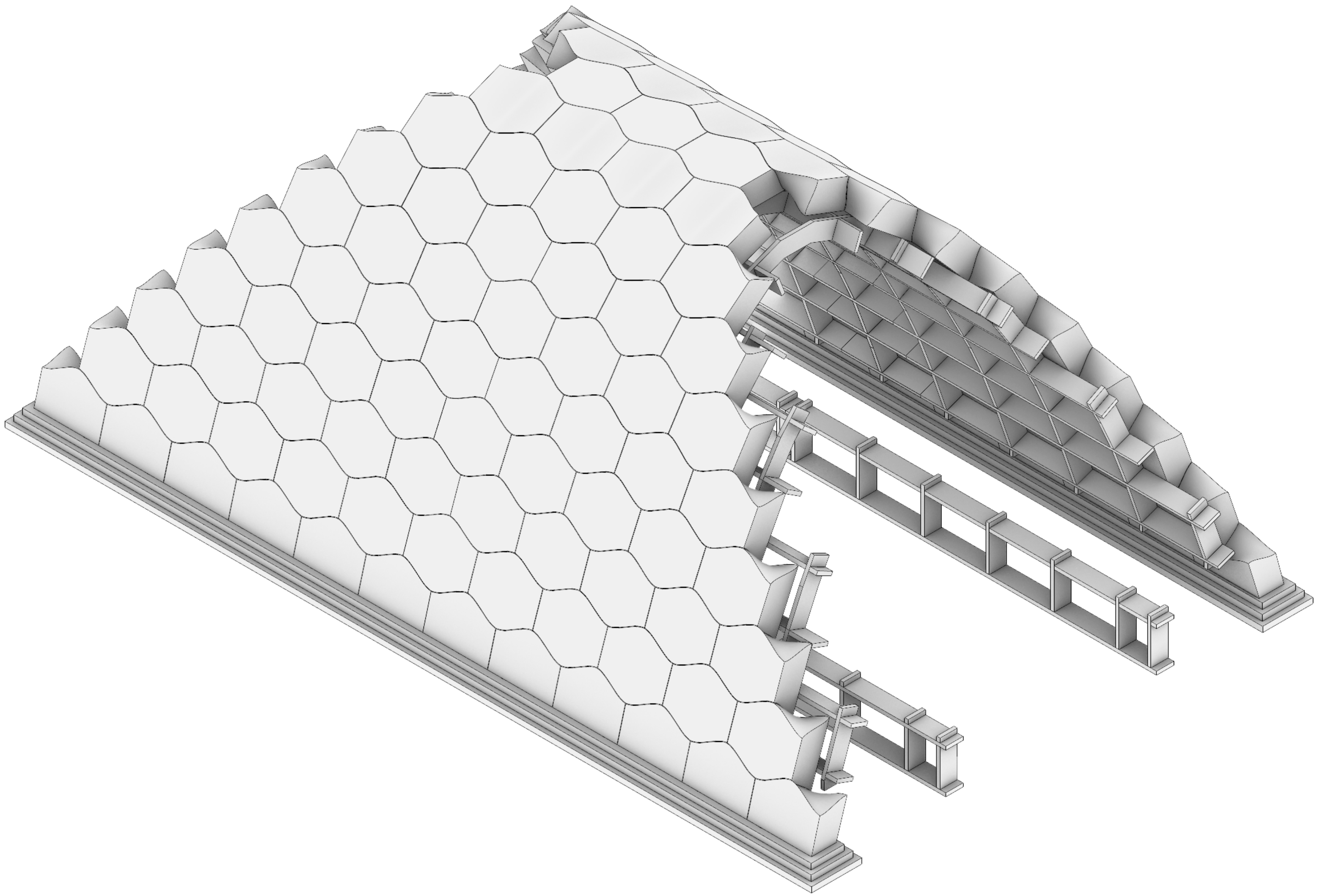
Assembly



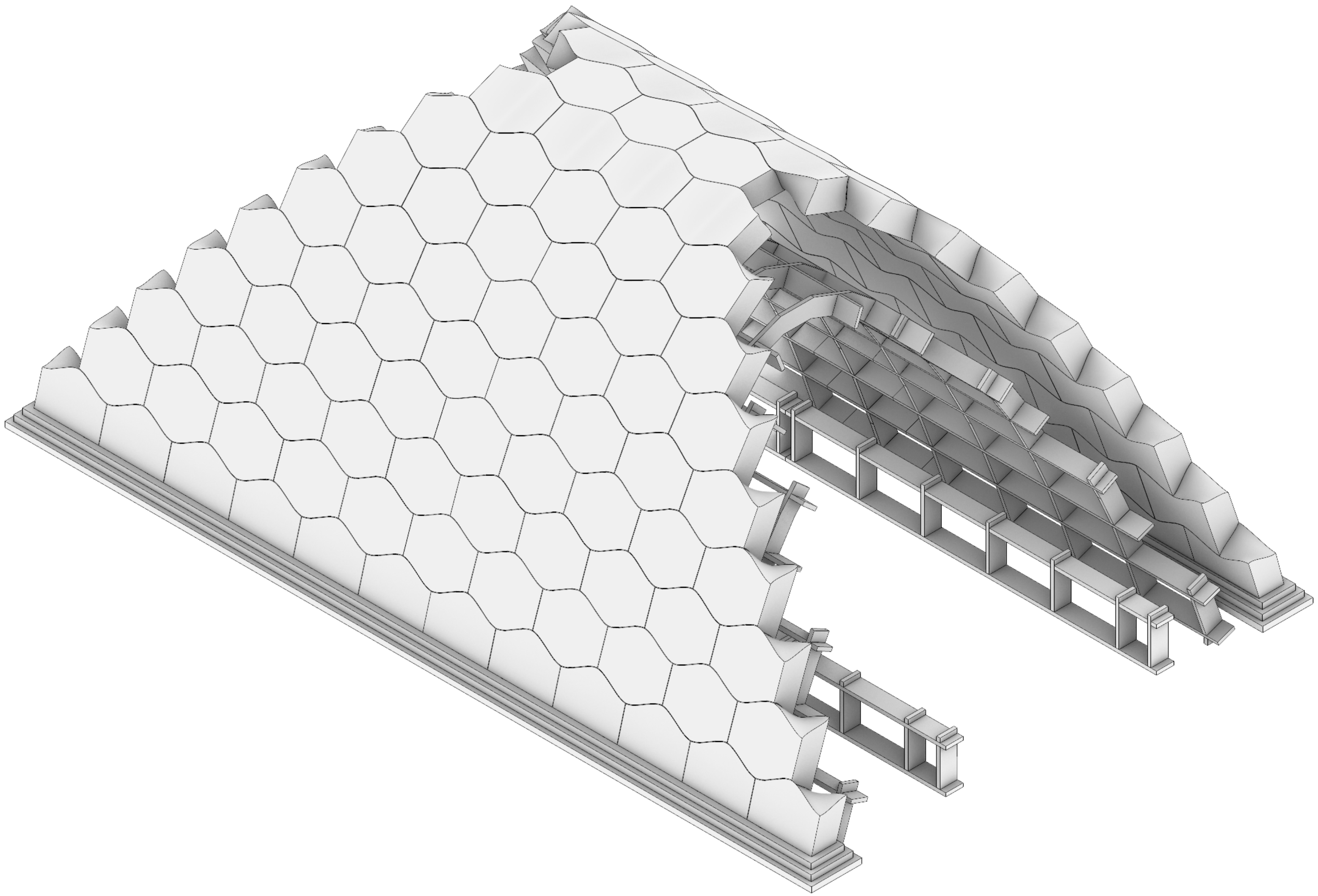
Assembly



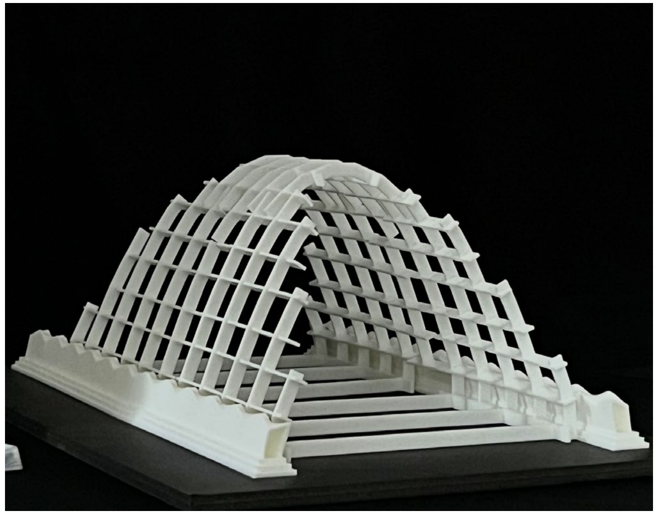
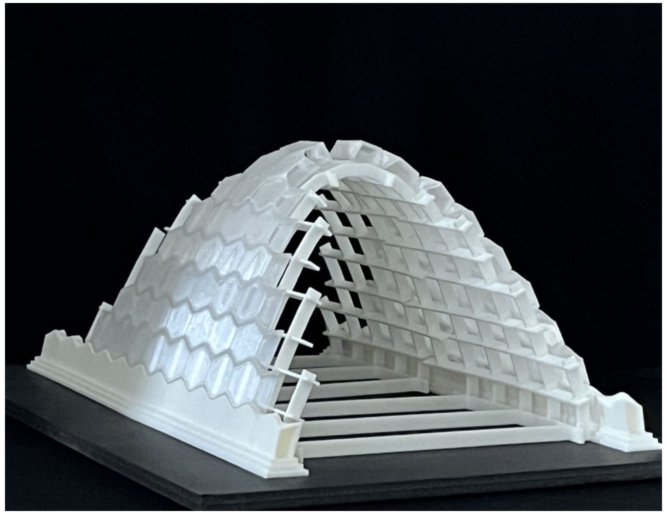
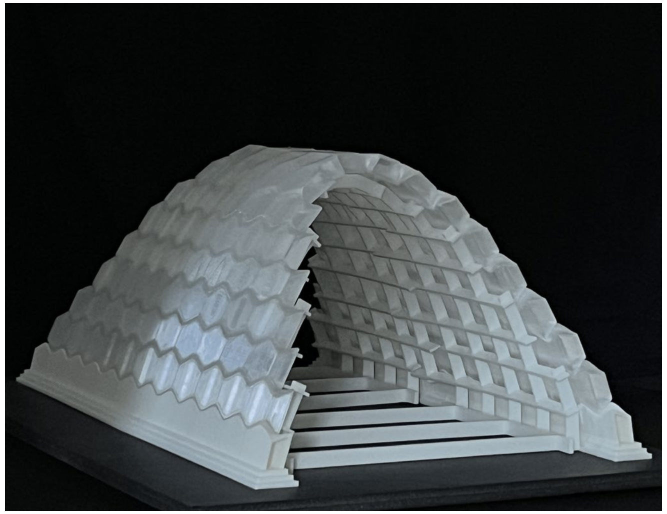
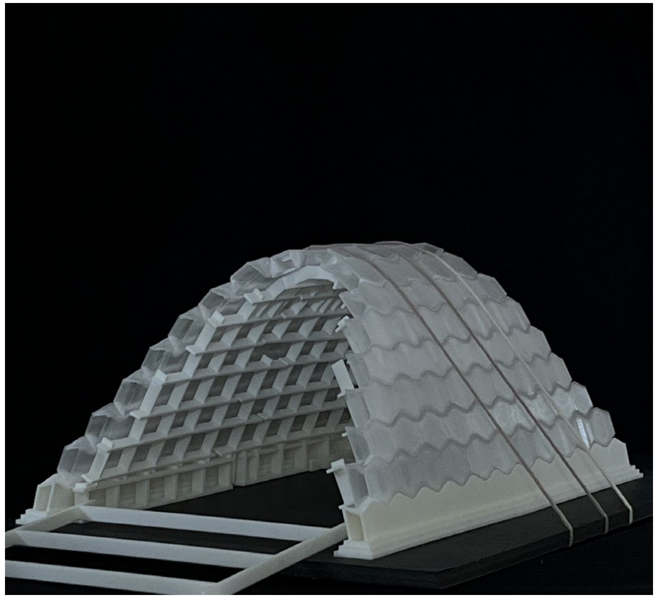
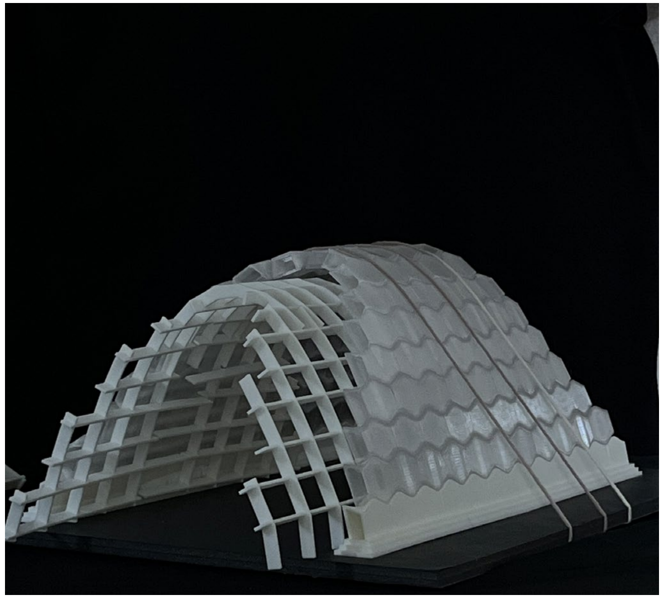
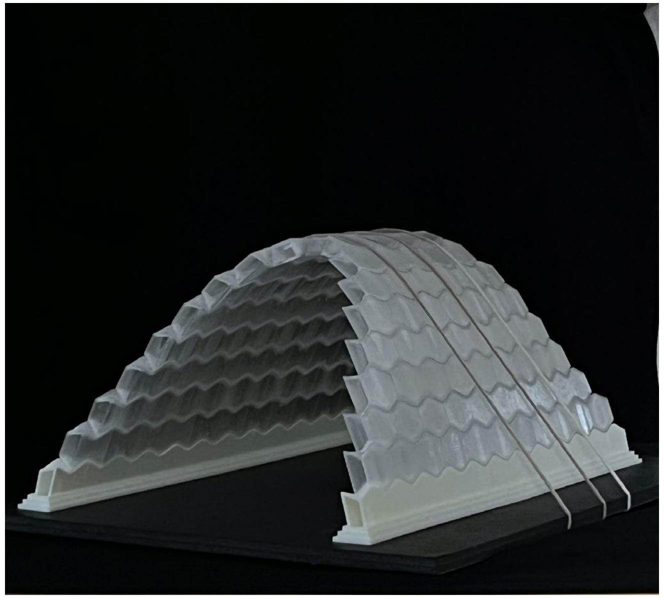
Assembly



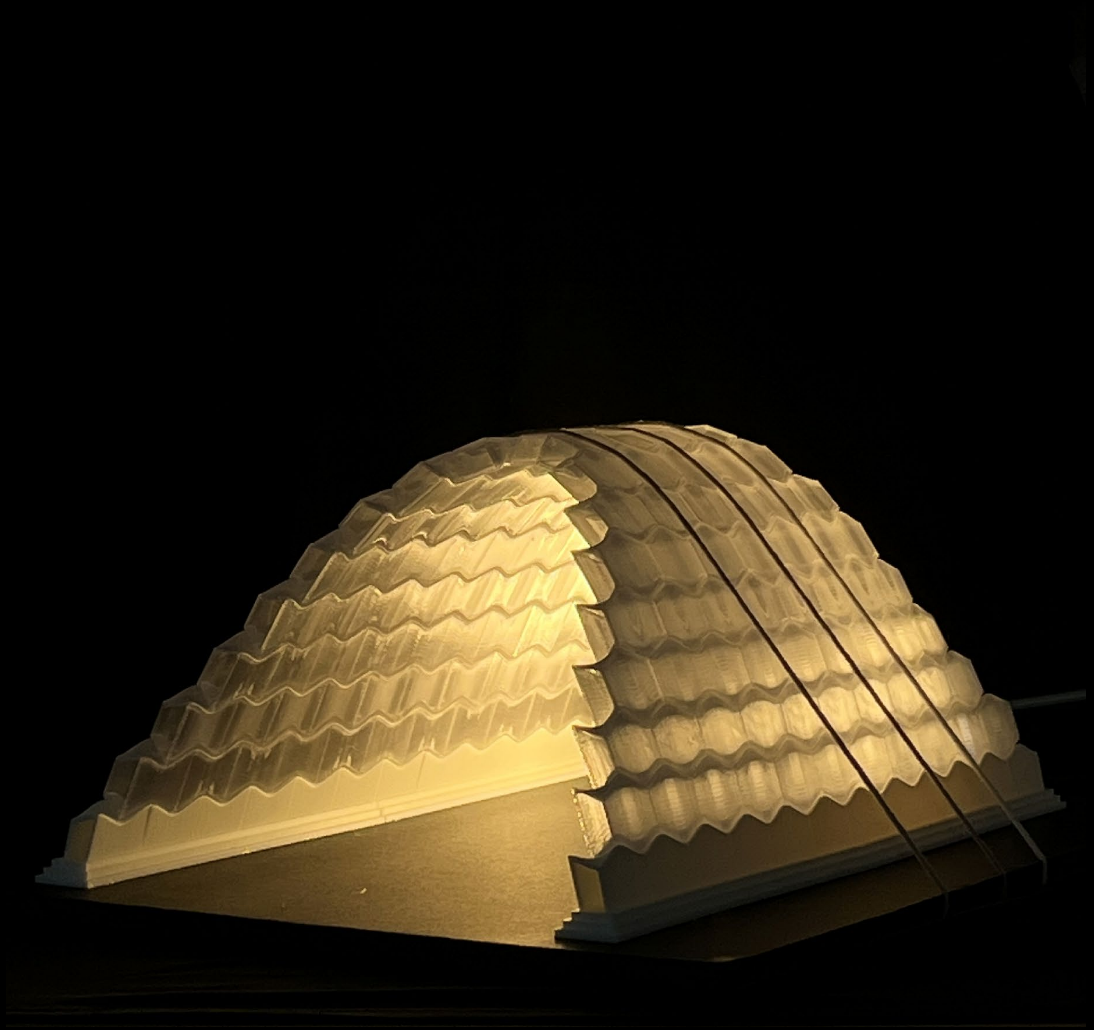
Assembly

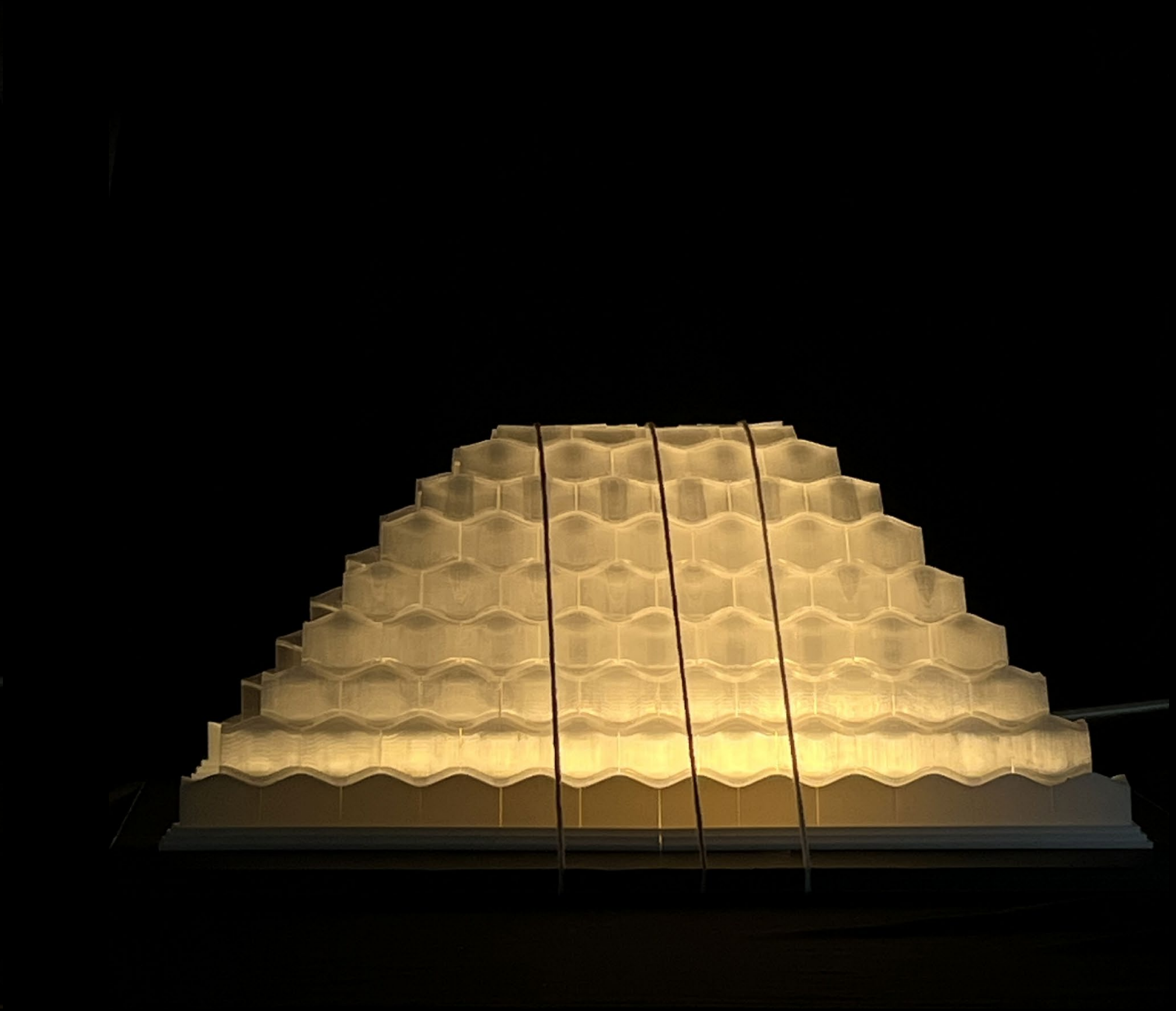


Assembly

Assembly





What is achieved so far:

- Developed strategies to tessellate different geometry forms for dry assembly
- Developed a Methodology for design and **optimization of the interlayer based on the geometry of assembly**
- Developed an **automation workflow** for grasshopper, and Ansys which allows parametric **Finite element analysis (FEA)** https://github.com/Nova7397/3DPGlassAssemblies
- Developed a strategy to convert the interlayer properties into stiffness an calculate the kirigami geometry for target property

Further Work:

- **Assembly Detailing and tolerances**
- **Formwork** design, **Support** detailing
- **Optimize the thickness of the vault** based on interlocking performance
- **Explore more options for the kirigami** interlayer- and assess their performance in contact with glass
- **Further optimize the interlayer stiffness** based on courses of bricks in the structure
- Design for adverse loading conditions and **derive a safety factor to** consider for dry assembly of glass

"This is not the final form, but the first layer- printed, Placed, and ready to support what comes next."

Thank you!

Questions?