parXshade

AR1B011 Bucky Lab Design 2
2021-2022

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scan here to see our
promotional video

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Glossary of terms

Spider
point holding system that connects the glass with the structure behind

Vacuum port
inlet position where the vacuum or other such device is connected to the system, located at the structure

Particles
the particles used in this report that will be in between the cavity, made out of polystyrene

CNC machine
computer-guided milling machine used to carve parts in a complex (3d) shape

Bottleneck
place where things would get stuck and clocked.

Vivak
transparent cheat of acrylic

System
with the system is meant all the parts that are needed to let the sunscreen function, sometimes it will also be used as another word for the prototype

static electricity
electricity that will build up inside the particles, maces the particles sticky against the Vivak.

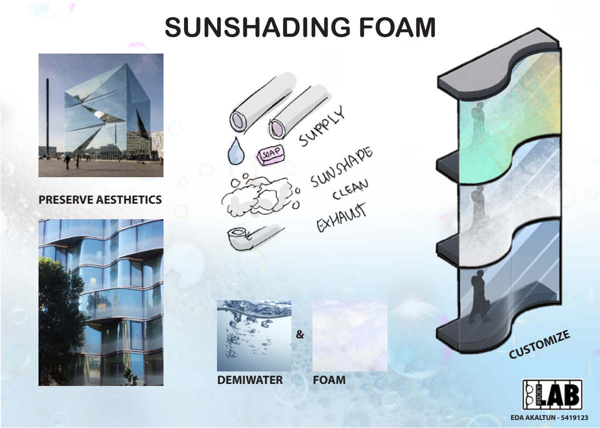
Cavity
when the word cavity is used in this report it will in most cases refer to the room in between the 2 front glass panels, as this one is used for sun shading. There is also another cavity in the back that is used for thermal insulation.

Introduction

This document is written for the course AR1B011 Buckylab Design. The purpose of the assignment is to design a sunscreen for an irregular glazed facade. In this report, we will share how we intend to tackle this particular design problem and the steps we have taken so far to make this happen.

The document is divided into different chapters. Firstly, it will start off by explaining what brought us together as a group through individual elevator pitches. Afterwards, the shared design vision is mentioned and explained. After that, based on the vision, the design soft and hard criteria are created, followed by a small argumentation. Next, our design process from past weeks is shortly summarized using sketches, pictures and a spreadsheet. To show the process that has
lead to the end product: Parshade.

Elevator Pitch

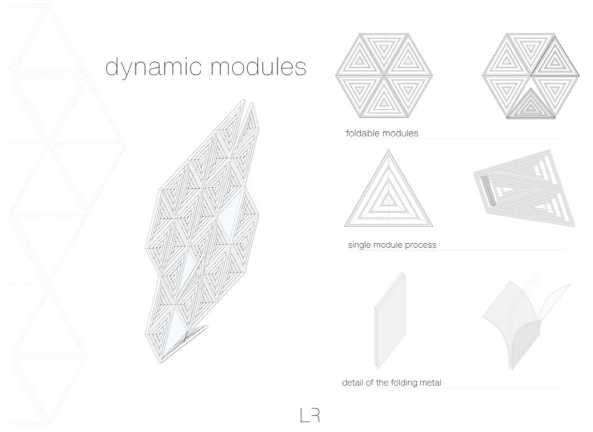


Eda Akaltun

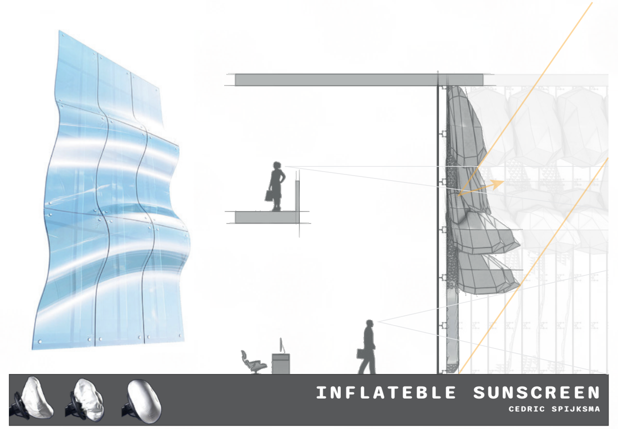
The concept lied its focus on using foam, which is an aesthetic and fascinating way of shading. This idea allowed the user to not see the sun shading system when it's not in use, but also colour the sun shading for occasions. The initial problem that this system tackled was multidirectional bent glass, foam is a sun shading "material" that adapts to the shape of the façade/cavity.

Oscar Chantrel

Granular materials can adapt to any irregular shape you put them in. The system works in the following way: on the top, there is a reservoir that's filled with a granular material, for example, sand. When you want to close the sunshade, the sand is dropped into a thin cavity construction. To open the sunshade, the sand falls into a second reservoir at the bottom. As the last step, the sand is transported back to the top reservoir using an Archimedes' screw.



Laura Romano



Cedric Spijksma

The concept of dynamic modules is based on having modular elements that can be moved and adapted concerning what is needed. Since many irregular façades are constituted by triangular shapes, the sun shading system will maintain this configuration.
Furthermore, the single modules have a specific design to get the so-called bi-metal that expands and folds at specific temperatures creating a proper sun shading.

The main goal of this concept is to go around irregular shapes. with an inflatable balloon, a couhon will form in front of the glass that will block out the sun. By the properties of a balloon, an interlocking system will form that will completely close off the facade.

What brought our team together is the part that we all wanted to create a system that would fit irregular multiple curved glass instead of just a set type of shape. we didn't want to create something that would fold or already existed or could olse by solving with just some roller blinds or curtains. The unique design of something in between the cavity in combination with the 3d shaped glass brought us together.

A sun shading is made out of particles, that can be applied inside the cavity of a multidirectional bent glass facade and that is not visible from the interior or exterior when not in use.

Why is this needed?
Glass is a great contributor to the heating problem of a building. Normal buildings do use sunscreens to block the sun on warm days to prevent overheating. For irregularly shaped buildings there are no sun shades available on the market. Moreso, multidirectional bent glass facades are becoming more popular. Especially for these types of facades, solid sunshade constructions are unsuitable. A granular material on the other hand can take any kind of shape.

This is why a sun shading made out of particles is the ideal solution for these kinds of facades.

design phase

Criteria

Hard criteria

The weight of the sun shading should not exceed 2.5 kilograms and 25 PSI per m2* (based on an estimated max pressure that a cavity in glass can handle)
The g value should be at least 0.2* (competitiveness with regular sun shading)
The shader should be able to disappear fully (from the glass parts of the facade) to keep full sight when the sun shading isn't needed.

The sun shading should be able to exist permanently when it is activated
Particles should be transportable through the cavity and in between storages to such an extent that the sun shading isn't needed; it should disappear in a maximum of 5 minutes.
The width of the sun shading shouldn't exceed 12 mm because the average cavity is 12 mm thick.
The sun shading system should withstand heat up to 120 degrees centigrade
The sun shading system should leave the cavity clean

Replacement and maintenance shouldn't take more than 1 day/system element
The particles should withstand UV to such an extent that the material doesn't discolour or erode in the first 5 years*.
Particles shouldn't have any properties that make them stick to the cavity or storage
The sun shading system should be not flammable

The Hard Criteria are made up of properties that would break the glass, would make it almost impossible to move, or doesn't make it comparable to existing sun shading systems. also, some key functions of our system can be seen as hard criteria, like the invisibility or looks

Soft criteria

The sun shading system should be sustainable, preferable made from recycled materials or biodegradable with a neutral carbon footprint
The materials used should be able to be reused or not harm the environment when being disposed
Parts should at least last for 30 years unless defined that they are easy to replace (within half a day)
The design solution should be simple, with fewer parts as possible (less replacement)
The sun shading should optionally have more than one stance besides open and closed
The system should be able to be controlled by the user

The Soft Criteria are developed by looking at the time spent and what the world/people ask for at the moment. these or mostly focused on the environment and some about user experience

The reason to choose a building is related to the feasible interconnection between the building itself and the performance of our sun shading panel.
Understanding the difficulties of finding a building that meets our needs, we separated two different ways to proceed in which the building has different characteristics:
1) Using secondary rope/beam construction like spider glass, which creates a facade system completely separate from the original load-bearing construction;
2) Attaching the top and bottom of large glass panes to the existing load-bearing construction;

Analysing the first point - that would be the more challenging one - there is the reservoir issue: since we still do not know how to manage the huge amount of particles having reservoirs just at the bottom and at the top of the building itself. However, this challenging point could satisfy many building variants' needs.
On the other hand, we kind of have a clear idea of how to approach the second point, since the reservoirs could be fit in every floor and each floor particle can fit the specific floor; this case is even more specific for people needs (in case of an office in which people want to control their sun shading system autonomously. The final choice is then the second case

1

2

1.

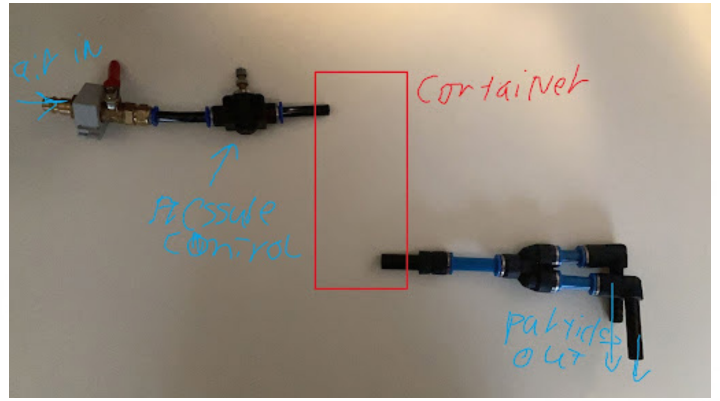
Transport system

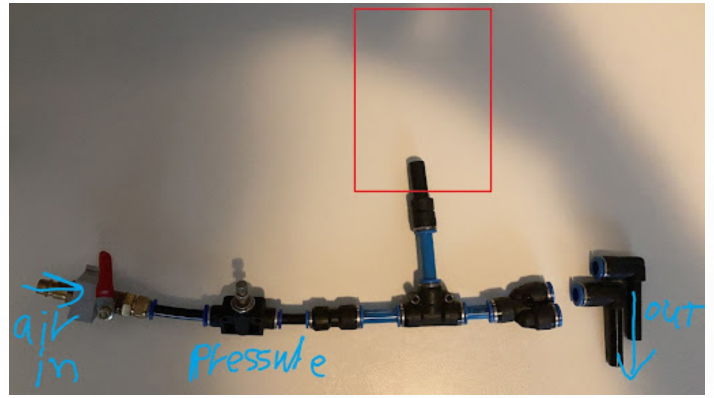
For the transport mechanism, different kinds were researched. We started by brainstorming and looking at how manufacturers and factories to transport goods. With ideas like Archimedes screws, pistons and belts were some of the options. We also looked into the tube systems used with tube mail and the vacuum systems. From this, we started prototyping. 3 prototypes were tested: Pushing system, Cascade system and tubing system.

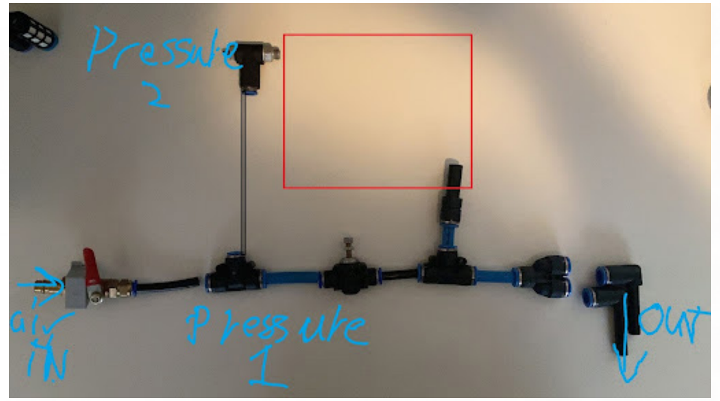
Transport system experiment: Tubing System

During these experiments, An attempt has been made to move particles through a tubing system. Firstly, by creating a venturi effect that would use gravity to move the particles to the pressurised tube, from where they will be blown inside the cavity. In this first attempt, the particles wouldn't go inside the tube so for the second experiment pressurizing the storage with some valves before the pressurizing of the storage and a valve for controlling the airflow through the tubes was attempted. Pressurizing did also not move the particles through. For the last experiment, a larger tube diameter was used. In this experiment, only the storage was pressurised. In the previous experiments, we found out that particles would get stuck inside the tubes and connections. Making the tubes bigger solved the problem of particles getting stuck inside the tube.

test 1: venturi effect	test 2: venturi with pressurizing storage	test 3: pressurized storage with large tubes
⌀6mm inner diameter	⌀6mm inner diameter	⌀12mm inner diameter
2-4 bar pressure	2-4 bar pressure	2-4 bar pressure
4 connections	4 connections	1 connection







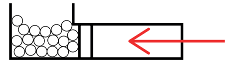
conclusion

Using tubes and pressurizing the system is an easy and cheap way to move particles. When designing it is necessary to take into account that the whole system must be able to be pressurized. Also, the diameter of the tube is of great importance. The tubes of 1,5 times the diameter of the particles would make them stuck. tubes with a diameter of 4 times the diameter would be big enough to move them through smaller distances.

further experiments:
trying bigger tubes with connections and blowing them inside the cavity, then try to remove them.

2. Transport system experiment: Pushing System

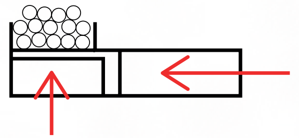
For this experiment, a maquette was made where particles could be pushed upwards. With this experiment, closing down a lid horizontally was also tested. The maquette was made of foam board and needles, with acrylic glass glued on it. The size of the frames on the sides and top are neglectable and were merely made this size for ease during the maquette process. See the images below for the outcome.

Test	1: initializing the particles	2: locking particles in cavity	3: releasing particles
Description	Pushing a surface towards the cavity in order to fill the cavity	Leaving the surface below the cavity in order to lock the particles inside the cavity	pulling back the surface in order to allow the particles to flood back to the storage
Method	A foam surface with a needle in order to push it like a drawer.	The foam board piece will be pushed to its limit and left there.	Foam board piece with a needle will be pulled back.
Result	The particles get stuck at the corner. Problem:  stuck	No problems occurred here. Due to the instability and cutting edges of the foam it wasn't perfectly locked, but this can be easily solved with other materials that are more stable.	A small amount of particles get stuck on the top part, but that might be because of the size of the connection or glue residue.

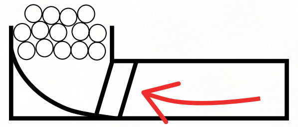


conclusion

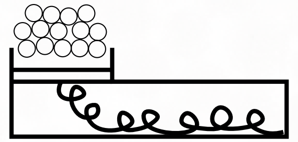
The particles get stuck at the corner. This can be solved by gradually pushing them up in batches, pushing them in a pattern or using a spring release to push them inside the cavity. For the push path method and the spring release method, the arc of the corner is very crucial. The gradually pushing up method involves something within the cavity which could overcomplicate the task even further.



gradually push up batches
slowest
(timing)



push path
medium
(arc issue)



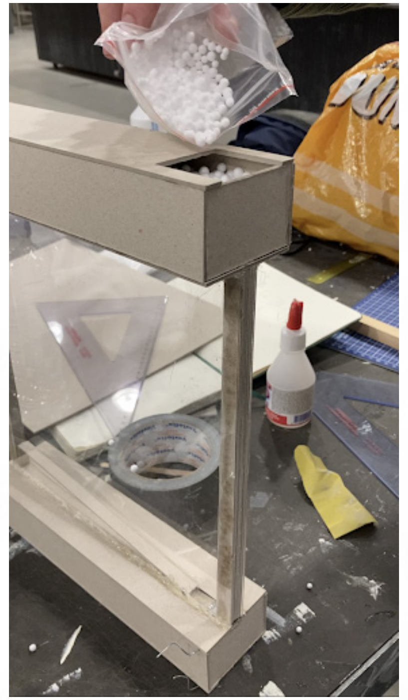
spring release
fastest
(how to push back)

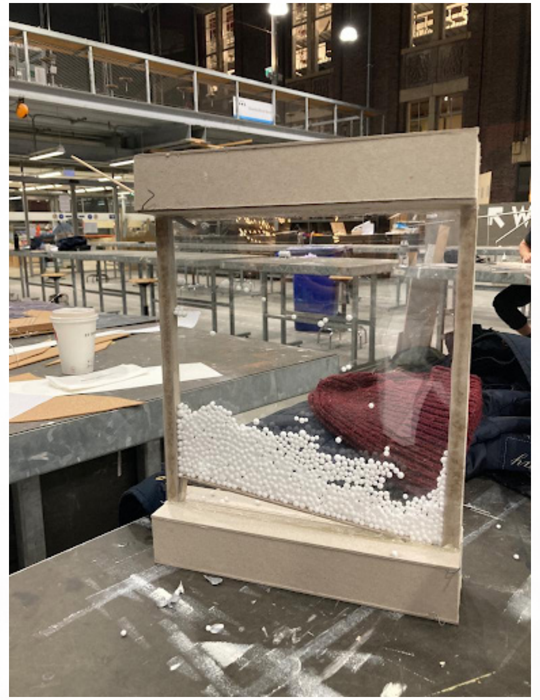
3

Transport system experiment: Cascade System

The design has a slope and manually controllable openings. This way, there's the least amount of materials used and the least amount of moving parts.

A physical maquette of 25 x 25 cm has been made out of Vivak (polyester) and cardboard. A cavity between the two Vivak layers of 1 cm has been made to let the particles pass through it. At both ends of the panel, potential reservoirs to simulate the reservoir of the single panel have been added and one of the higher floors as well. Furthermore, a rough system using slopes to let the particles pass from the first reservoir has been made, that goes through the cavity, into the lower reservoir. A small hole shave been made in the reservoir aligned to the glass panel (having the same depth), with iron wire handles to open and close them.





conclusion

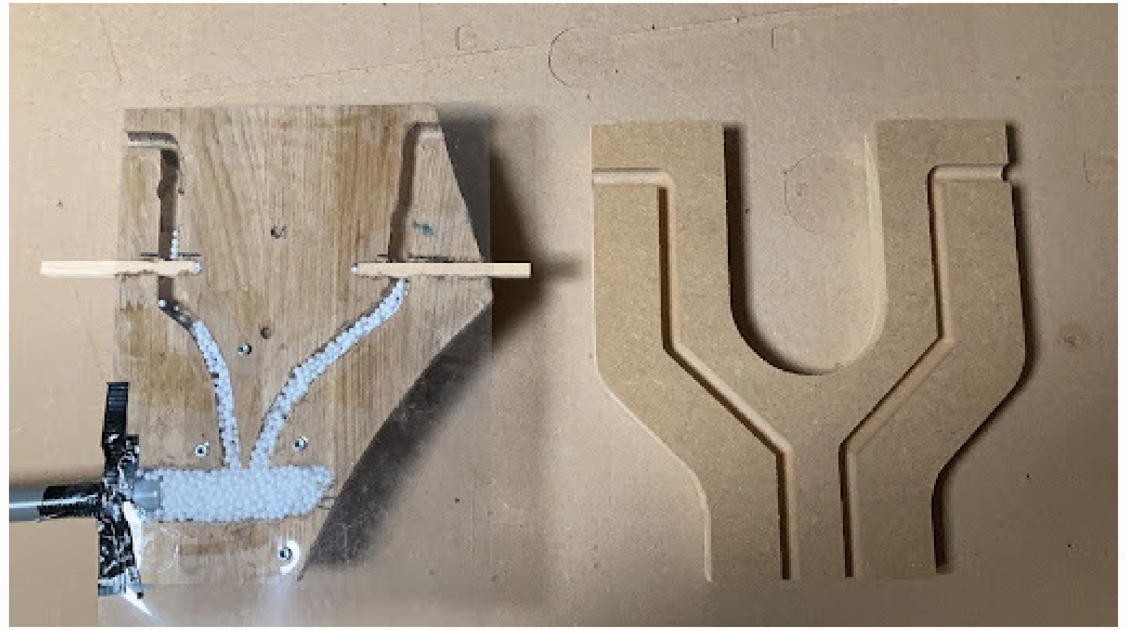
The most difficult part was the mechanism to open or close the reservoirs. This part in the future would need to be detailed very carefully. Furthermore, the main problem faced is when testing the model, the static of the styrofoam grains. Because of this, the particles didn't roll down into the cavity as easily as anticipated. Therefore, for the next test, it is better to test another material that hasn't got material properties that cause static, such as plastic granulates. After that, a better evaluation of the model can be made. As of right now, the model doesn't work sufficiently because of the aforementioned reasons.

To improve the current model so that we could use styrofoam, bigger openings into the cavity would be needed. Another solution could be steeper angles of incline of the ramps from which the grains roll down into the cavity/reservoir. However, this is not a space-efficient solution. So for styrofoam, probably different solutions will be necessary, such as making an opening that's as wide as the entire cavity or pressurizing the system to force the styrofoam to move, since gravity alone apparently isn't enough. Or alternate solutions to making particles anti-static can be researched.

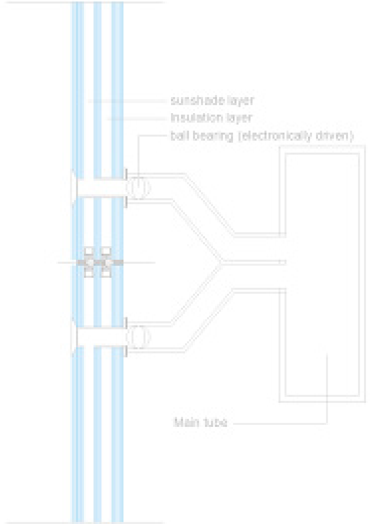
Transport system experiment: Next Steps

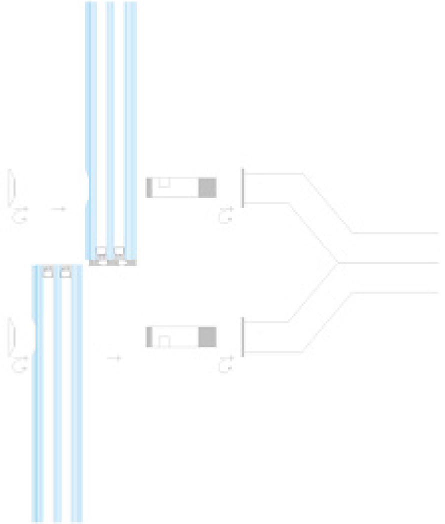
After those experiments, the decision has been made to continue with the tube system. As it would be possible to make it really small and even possible to make the vacuuming centralized.

For the transportation, we started with testing different kinds of tubes. A vacuum cleaner did great work (round 32), then we tested some Festo tubes (around 8-10mm in size) and later we tested some electrical tubing (16-20mm in size) we found out that for the pe particles the Festo tubes were too small. The electrical tubing worked well, as long as there were not too many curves.



The next part of the transport system was developing the spider part. We started with a hand-carved spider where we used a router to follow a line. In this test, we used a 9mm round-over bit. After the testing, we found out that the particle got stuck in the tracks. Because of the irregularities, the next test was CNC carved (will be explained in another chapter) also the wood type was changed to a more smooth type. After testing this part the particles still got stuck in the corners. so the next step was to round over these corners for a smoother flow. This would solve more of the backups but after more runs, the particles would still get stuck. To solve this problem we decided to enlarge the cavity and the tubes, so we ordered a 19mm round over bit, and redid the CNC carving. After this, the transport through the spider worked well.



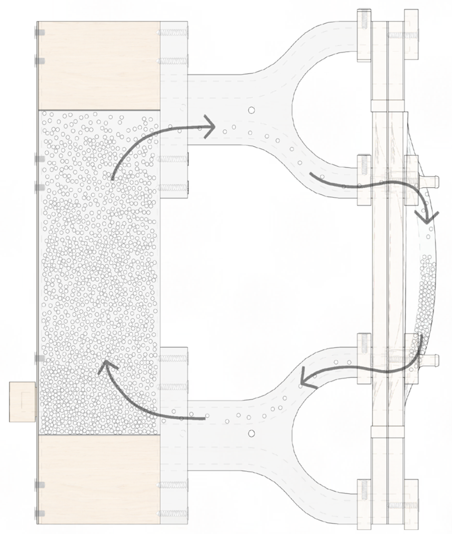


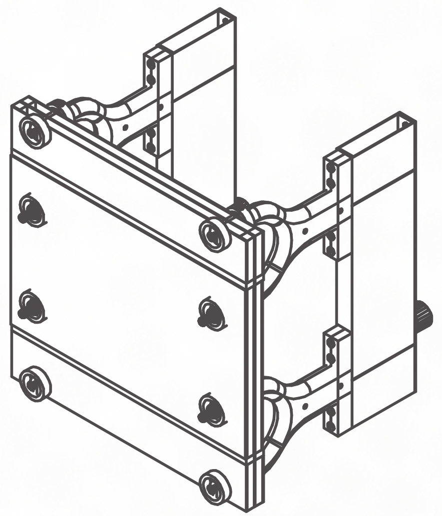
After the system worked with ps particles we also tested some other particles like rice, plastics and coco pops. all the other materials got stuck except for the ps.
During the building weeks, we tested the transport system on a bigger scale. For findings from building weeks, see the corresponding chapter.

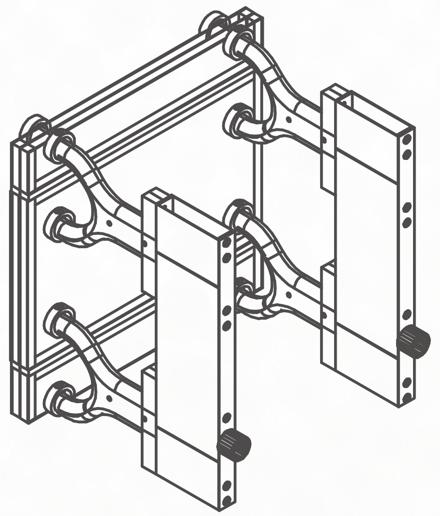
Final Transportation System

After the system worked with ps (polystyrene) particles we also tested some other particles like rice, plastics and cocoa pop. all the other materials got stuck except for the ps.
During the building weeks, we tested the transport system on a bigger scale. For findings from building weeks, see the corresponding chapter.

In the end, the conclusion is to go on with the tube system. In a real-life scenario, this would translate into hollowed-out point holders. there should also be a connection to the structure behind it. to close off the system per glass pane, divisions should be made in the spider as in the structure. The nice part about this system is that it can be powered from a centralized area, like a basement or technical room. a vacuum machine and compressor would be located over here. This vacuum/compression can be used all over the building with another interconnected tubing system. with valves closer to the windows the opening and closing can be controlled.







Materialization

As explained in the chapter previously about the system's criteria, some of them had a great influence on the material choice. All those criteria will be implemented in Granta Edupack 2021 to filter out unrealistic materials that do not meet the hard criteria:

Hard criteria

Density:
Consulting Fred Veer in terms of the amount of density a cavity can handle, with the picture below as reference, it was concluded that 6 mm glass can withstand 3m water pressure (aquarium), which is a density of 1500 kg/m3. Therefore all materials will be filtered on this property. This value is the maximum that can be held while the entire cavity is filled.

Transparency:
Translucent versus opaque. In Edupack the given properties will be for the material, not for the entire sun shading system, therefore the filter for both Opaque and Translucent has been used.

Melting point:
Based on the location of the project. Filtered for max 120 C (Source: Regina Bokkel)
https://urbanalyse.com/research/facade-temperatures/

UV radiation:
Since we're designing a sun shading system, the material should be able to withstand UV radiation. This will be filtered on good and excellent in Edupack.

Flammability:
The sun shading system shouldn't be flammable. Self-extinguishing and non-flammable.

Size:
Maximum 6 mm (overwritten by transport criteria 19, criteria 6 left out)

Soft criteria

Price:
100 euro's per m2

Environmental Hazard:

Material Lifetime:
30 years (Eco audit)

Sustainability:
The production process of the granulate should be as simple as possible to save energy. For the material choice, a repurposed (ideally even bio-based) material is very fitting for a granular product that requires little to no processing. Below (next page): plot in Edupack of all materials, comparing density and Embodied energy. This plot shows how much less embodied energy is used in the production process of natural materials. Especially cork pops out with both a very low embodied energy and a very low density.

This filter with only the hard criteria leaves us with 90 results.

Within the 90 results, the following group of materials exist:
Material families:
Ceramic non-technical
Ceramic technical
Plastic
Metals

Alumina foam
Aluminum-SiC foam
Cordierite foam (0.5)
Mullite foam
Silicon carbide foam (0.5)
Yttria zirconia alumina foam (1.20)
Zirconia foam
Aerated concrete
Brick (low density refractory)
Concrete (insulating lightweight

Carbon
Graphite (premium industrial)
Graphite foam (0.12)
Plaster of paris
AES (flame retarded)
LCP
PBI
PBT
PC+PBT
PCT

PCTA
PEEK
PEI
PEK
PEKK
PI
PLA (flame retarded)
PPS

As can be seen from the list, all the materials are ceramics, plastics or metals.

To find the ideal material to serve as a particle, Edupak will be used to filter all materials that don't meet the hard criteria. After having done this, the materials will be evaluated based on the soft criteria and how well they perform in terms of the hard criteria.

For this, a multi-criteria analysis has been made, with manual input of experience and the values from Edupak as a reference.
For this multi-criteria analysis, the criteria have gotten the following weight factors:

	Cost	weight	aesthetics	transparancy	cleanability	noise	sustainibility
cost		1	0	0	1	1	0
weight	0		0	0	0	0	0
aesthetics	1	1		0	1	1	1
tranparency	0	1	0		1	0	0
cleanability	0	1	0	0		0	0
noise	0	1	0	1	1		0
sustainibility	1	1	1	1	1	1	
Weight factor	0,2	0,6	0,1	0,2	0,5	0,3	0,1

Explanation

Sustainability and aesthetics of the particles are valued least when compared to the other criteria since these criteria are critical for the system to function according to the design vision. Heavy particles are way harder or impossible to transport and particles that leave traces within a cavity that is hard to clean are deal breakers for the sun shading system.

Material	Cost	Density	aesthetics	transpanancy	cleanability	noise	sustainibility	embodied energy	carbon footprint	reusability	score	cost m3	cost m2	density	embodyd energy/m2	embodyd energy	carbon footprint/m2	carbon footprint	reusability
Weight factor	0,27	0,64	0,18	0,27	0,55	0,36	0,18				-								
Aluminum-SiC foam	4	5	4	5	5	5	1	1	1	1	11,09	1140	13,68	68	5,147	350	0,338	23	downcyle
Silicon carbide foam	3	5	4	5	5	5	1	1	2	1	10,88	2120	25,44	500	0,280	140	0,016	8	downcyle
Alumina foam	2	5	4	5	4	5	3	1	3	4	10,30	3390	40,68	500	0,070	35	0,005	2,6	recycle
Cordierite foam	1	5	3	5	5	5	2	1	3	1	10,21	5000	60	500	0,130	65	0,007	3,4	downcyle
Mullite foam	1	4	4	5	5	5	2	1	3	1	9,76	5920	71,04	690	0,087	60	0,005	3,5	downcyle
Zirconia foam	1	4	4	5	5	5	1	1	2	1	9,70	38100	457,2	740	0,208	154	0,011	8,5	downcyle
Yttria zirconia alumina foam	1	2	4	5	5	5	2	1	3	1	8,48	62000	744	1170	0,137	160	0,008	9	downcyle
Graphite foam	4	5	4	1	2	5	1	1	1	1	8,36	1090	13,08	120	0,781	93,7	0,042	5,05	downcyle
PLA (flame retarded)	2	1	3	5	5	3	4	4	4	4	7,64	4000	48	1260	0,017	21	0,001	1,2	recycle
Aerated concrete	5	4	3	1	3	1	4	5	4	4	7,52	50	0,6	600	0,001	0,8	0,000	0,065	recycle
Concrete (insulating lightweight	5	2	3	1	5	1	4	5	4	4	7,33	50	0,6	1100	0,003	3,15	0,000	0,25	recycle
Carbon	4	1	1	1	5	5	3	4	4	1	7,27	1800	21,6	1300	0,020	25,5	0,000	0,27	downcyle
PPS	1	1	3	5	5	3	3	1	4	4	7,18	6500	78	1340	0,056	75	0,003	4	recycle
PEEK	1	1	2	5	5	3	3	1	4	4	7,00	68200	818,4	1300	0,077	100	0,004	5,5	recycle
PI	1	1	2	5	5	3	3	1	4	4	7,00	35000	420	1400	0,082	115	0,005	6,3	recycle
PEK	1	1	1	5	5	3	3	1	4	4	6,82	109000	1308	1290	0,084	108	0,005	6	recycle
PEKK	1	1	1	5	5	3	3	1	4	4	6,82	100000	1200	1300	0,083	108	0,005	6	recycle
PC+PBT	2	2	2	1	5	3	3	1	3	4	6,76	4000	48	1250	0,096	120	0,006	7	recycle
AES	1	2	2	1	5	3	3	2	4	4	6,61	6000	72	1050	0,033	35	0,001	1,4	recycle
PBT	2	1	2	1	5	3	4	3	4	4	6,30	3500	42	1450	0,025	36	0,001	1,8	recycle
PCTA	2	1	3	0	5	3	2	1	4	1	5,91	3250	39	1360	0,092	125	0,005	6,25	downcyle
LCP	1	1	2	1	5	3	3	1	3	4	5,85	14300	171,6	1400	0,154	215	0,009	12,5	recycle
PBI	1	1	3	1	5	3	2	1	2	2	5,85	200000	2400	1290	0,271	350	0,016	20	incinerate
PCT	1	1	2	1	5	3	2	1	4	1	5,73	10600	127,2	1440	0,083	120	0,005	6,5	downcyle
Brick (low density refractory)	2	3	2	1	3	1	3	5	4	1	5,70	3710	44,52	800	0,001	0,85	0,000	0,12	downcyle
PEI	1	1	2	1	5	3	2	1	3	1	5,67	17200	206,4	1400	0,118	165	0,006	9	downcyle
Graphite (premium industrial)	1	1	4	1	2	5	1	1	2	1	5,06	19000	228	1600	0,144	230	0,011	17,4	downcyle
Plaster of paris	4	1	2	1	1	1	3	5	4	1	3,88	2000	24	1500	0,002	2,25	0,000	0,2	downcyle

Cost:
Graded based on Edupack values. A lower price is better.

Density:
Graded based on Edupack values. Lower density is better.

Aesthetics:
The aesthetics of each selected material is selected from a personal point of view. The grades are 1 to 5 about what we think has a better aesthetic.

Transparency:
The material has not to be transparent since we are referring to materials that have shading functions. The grades are 1 to 5; 1 is transparent and 5 is opaque.

Cleanability:
The material should not leave traces behind in the cavity, as that is a hard place to keep clean. The following point system has been used to distinguish materials:

1. dirty
2. leaves traces
3. leaves smaller pieces
4. somehow leaves stuff behind
5. leaves nothing behind

Noise:
The amount of noise that is made when the particles drop on themselves. 5 is almost no noise, 1 is a lot of noise.

Sustainability:
The sustainability criteria are based upon three measured values from Edupack: carbon footprint embodied energy and reusability. For both carbon footprint and embodied energy a value of 1 to 5 is given based on the amount of energy required or carbon emitted during the production of 1 kg of material: less is better. For reusability, the following grading system is used, again based on data from Edupack: 5 = reusable, 4 = recyclable, 3 = downcycle, 2 = incinerate 1, = landfill.

Excursion Innovation Center Rotterdam
To find out about more innovative and sustainable materials for the cavity filling, an excursion to the 'Innovatie Centrum Duurzaam Bouwen' in Rotterdam was held. Some interesting materials were on display here, such as cork insulation, insulation particles based on maize and other vegetation, insulation based on old cardboard and low weight chalk based insulation particles. None of these materials could be found in Edupack, except cork, so it was a nice way of discovering some more innovative materials.

Conclusion Material

Right now some of the most promising materials evaluating are foams: especially, aluminium foams seem to have a lot of potential, however, it will be difficult to obtain granulates of this material. A quick internet search shows that these materials need to be ordered from abroad (China) with a minimum batch of 1000 to 10.000 units. Making it less suitable for the prototype, but a potential solution for in practice. Similar to this, numerous materials from the Innovation Centre are quite difficult to come by. The same applies to other potentual candidates like silicon carbide foam. Because of this, (expanded) plastics probably are a more obvious and easier to acquire choice that also has an average to a good score. Therefore, plastics will be used for the prototype.

For the real sun shading system, the listed foams in the table can be tested and considered when they are more accessible.

final product

Real-life scenario:
The previous sketches and materialisation were all based on the prototype we had to make. in a real-life scenario, other materials would be a better choice and other shapes can be chosen.

Glass & Glass expansion:
The multidirectional bent glass is the outer layer but also the inside layer for the cavity of the system. The glass will be held by a point, better known as point hold glass. To prevent the breakage of the glass through expansion, the spider will have a horizontal slider space on one side to hold the glass from the top, and a fixed point on the other side on top. On the other 2 parts that are for the lower part of the glass, it has 2 points that can go both ways.

Spider Material:
For the prototype, wood will be used as it is easy to come by and easy to shape/machine. In the case of a real spider system (stainless), steel or aluminium is used and is made up of different parts that are screwed together. this would also be machined or even cast.

Vacuuming:
For the prototype, a vacuum cleaner is used to suck and blow the air out of our product. In a real case scenario, a giant system can be placed in the basement that changes from blowing and suction. with valves, at the vacuum ports(prototype) the system can be controlled. for now, there is a vacuum hose attached to the structure, in real life this should be an additional pipe at the back of the structure that will be used for the whole row of panels.

For the vacuum port, a filter is needed. In the prototype, a sock is used. for a final product, a fine metal mesh would work as it is more durable. it should be smaller than the particles.

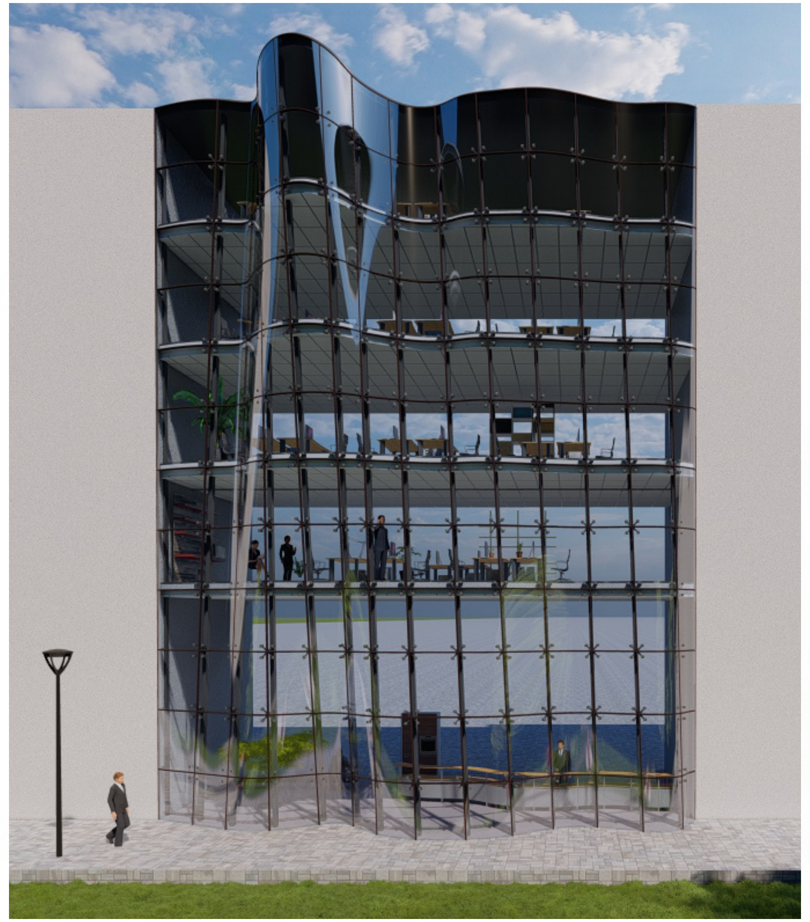
Static Issue:
Fixing the static problem in real life would be a lot easier with the different kinds of materials. where we had to add chicken wire and grounding it in the prototype, the real-life scenario the metal parts could just be grounded to solve the static electricity problem. also changing the polystyrene to alumina foam would solve the problem. if the problem still arises anti-static spray could be used.

Spider glass is only one type of point hold glass: there are a lot of different systems available, for example, a cable net facade which is used in the Markthal in Rotterdam. Parshade utilizes a connection very similar to the spiders of regular point fixed spider glass. The reason why this type is chosen over different systems is that the spiders due to their shape inherently create a way to easily divide the supply and discharge of the particles. To achieve this, the spiders used in the Parshade system are hollow, in contrast to a lot of standard spiders that are solid, which also makes them slightly thicker.

However, not only the type of connection comes in various shapes. The load-bearing construction behind the spiders also can vary enormously. For Parshade, these variations are very important as not all construction types suit the concept: a load-bearing construction that doubles as a storage system for the particles. Parshade is therefore optimized for constructions such as the one in the top right on the page above. It however can be easily altered to fit buildings with horizontal secondary load-bearing constructions such as the picture in the bottom left.

However, problems occur for designs that desire glass fins or cables as their secondary construction layer. For these cases, different solutions ought to be sought. In the case of glass fins, an idea could be to create transparent reservoirs instead of glass fins. This does cater to the aesthetic architects often have in mind when choosing for glass fins but also creates an amusing sight where one can see the entire process of the sunshade closing and opening.

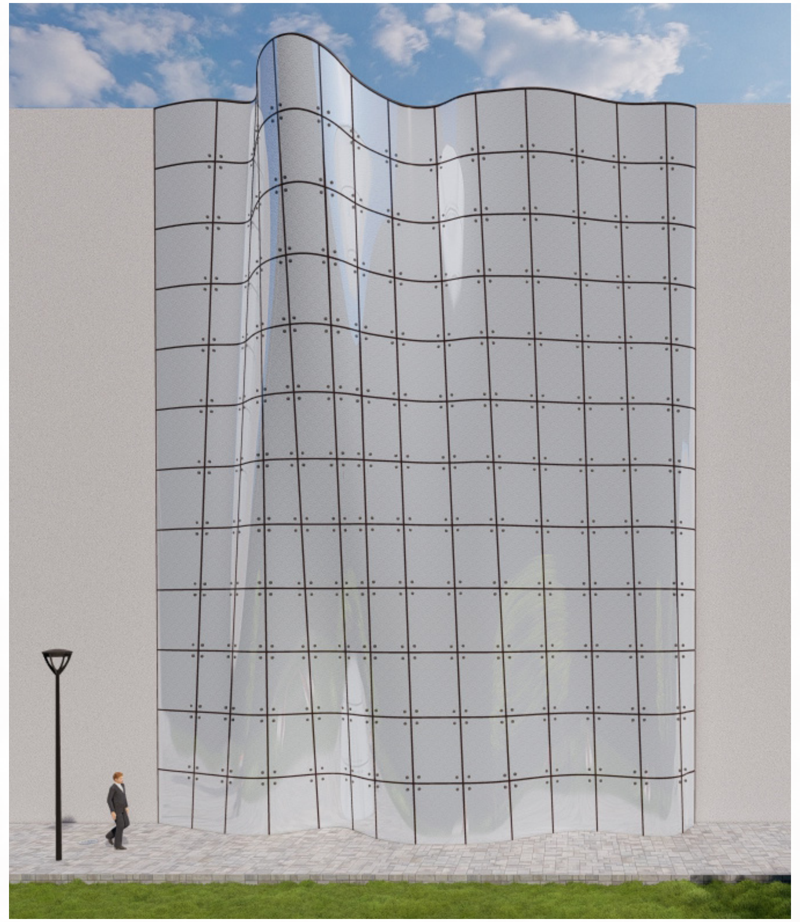
For rope constructions, external storage systems are almost inevitable. These could be located in the primary load-bearing construction for the roof for example. The supply and discharge can be connected to the spiders via tubes that are routed along with the rope construction. This is a time-consuming process though and it arguably doesn't always match the desired aesthetics of a design.



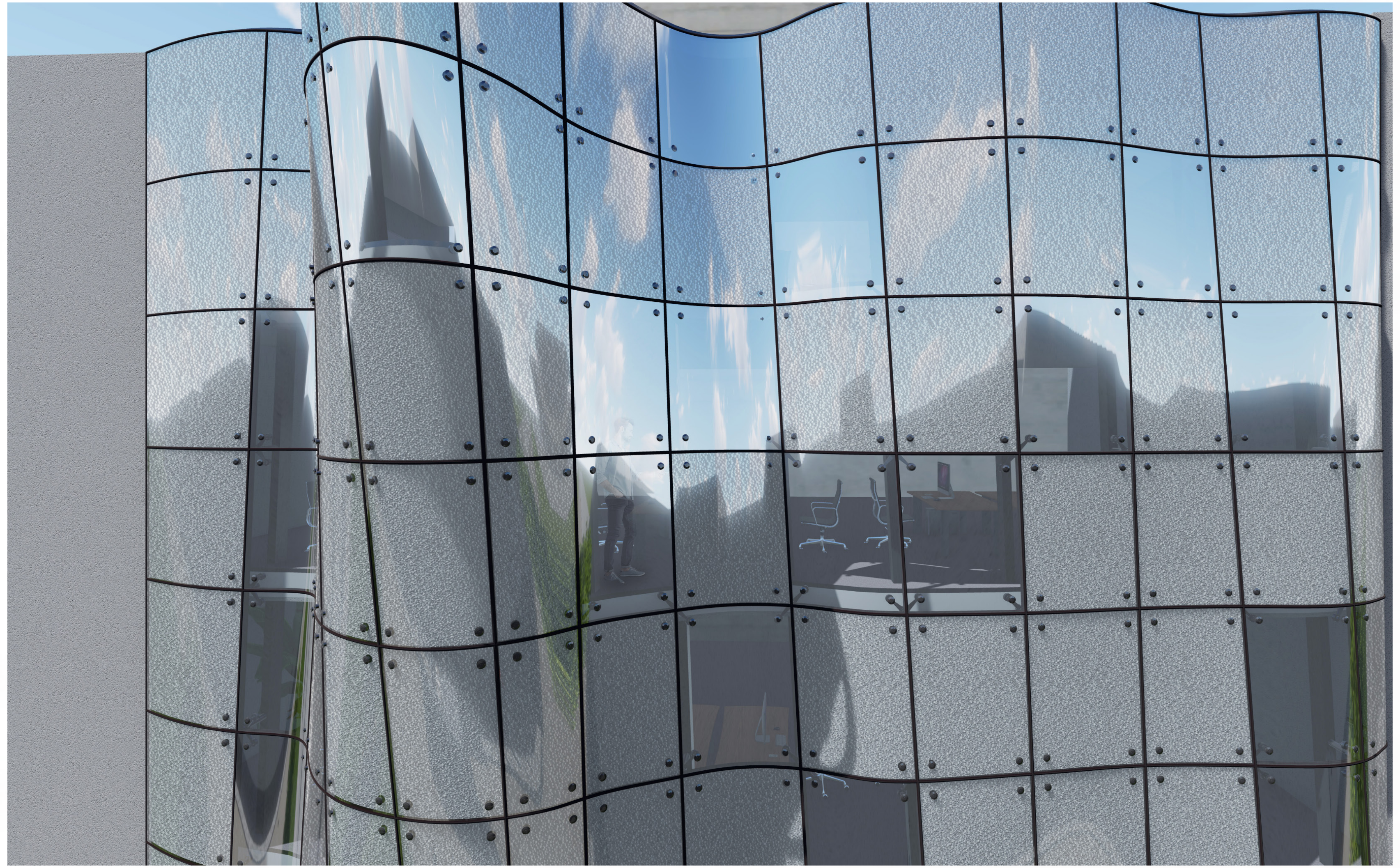
Real Case Scenario having particles in the storage, meaning the sun shading is not working at the moment

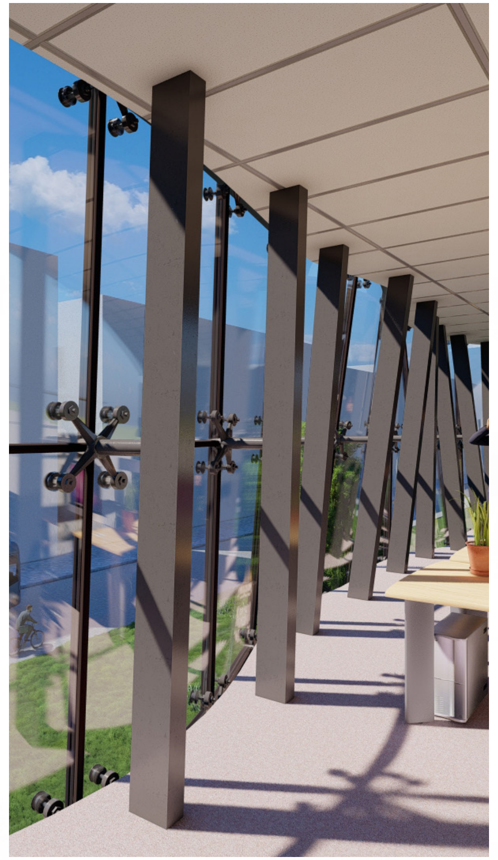
Real Case Scenario having specific panels filled with particles showing the versatility of the product

Real Case Scenario having specific panels filled with particles creating an aesthetical pleasing façade



Real Case Scenario completely filled with particles, showing that the identity of the façade is maintained





Internal View of the real case scenario showing how the light is transmitted to the inside

Internal View of the real case scenario showing the specific filled windows, so that the internal space will not be completely dark

Internal View of the real case scenario showig all the filled panels, meaning that the sun shading can be 100% efficient as well

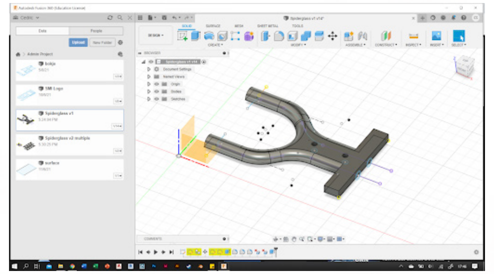
prototype

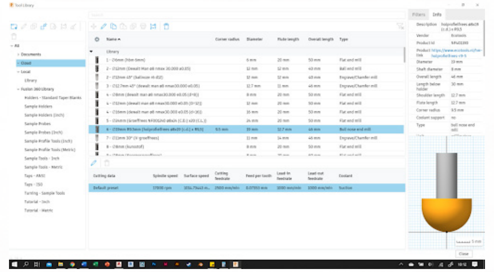
Scaling to prototype - Spider

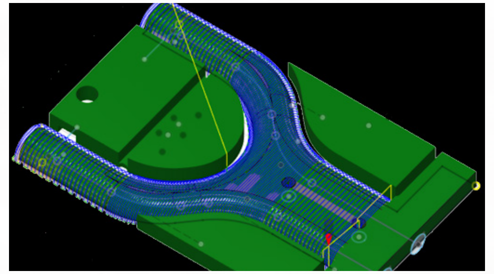
In the real case scenario of the sun shading system, the "spider" (the point hold glass) will be cast in aluminium or (stainless) steel. Since this isn't achievable for the prototype, wood will be used with a CNC machine. CNC milling is also known as Computer Numerical Control milling. It is an automated way of controlling a mill/spindle. using a CNC mill, complex 3d shapes can be formed out of a piece of material, also called stock. A CNC Mill will remove parts of the stock to create the 3D shape. The machine will be controlled by a pre-programmed path, which in most cases is written in G-code, a programming language.

The sun shading system that is designed has a complex 3D geometry called "spider"; this part will be used to move particles from the storage to the inside of the glass cavity. The material for this will be plywood, as it is a common material for CNC milling and will also be provided by the university.

Before a CNC mill can do its work, a 3D model is needed. With the 3D model, the programmer can select the needed tools and generate the path the machines need to follow. This program is exported as a G-code and loaded onto the machine. From here on the machinist can place the stock on the machine, select the defined tools and set the origin for the stock. From here on the machine will do its work.


3d model

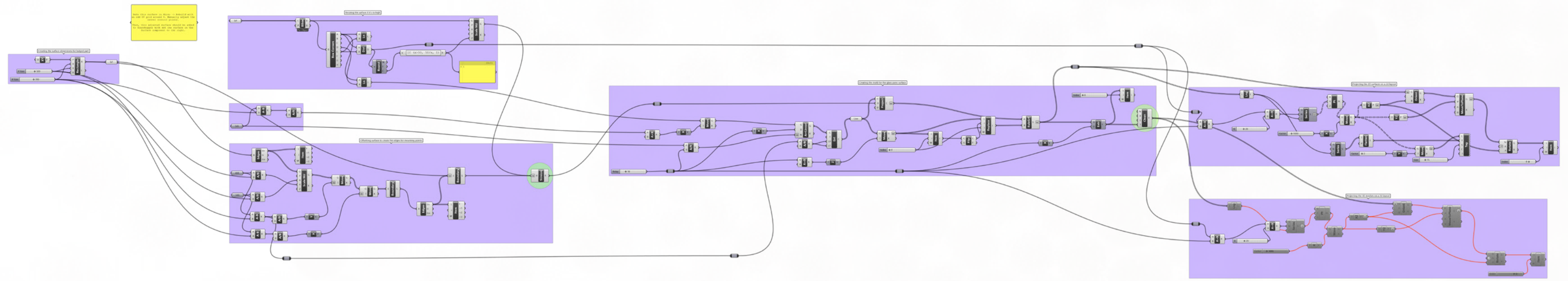

Tool selection


Tool path generator

Scaling to prototype - Bent Glass

In the case of the prototype, a multidirectional bent glass of course wasn't an option. For the prototype of Parshade, Vivak, a type of polyester, will be used to simulate this bent glass. Vivak is chosen because it's extremely easy to shape but also relatively impact-resistant, so it can handle some rough production techniques. Also, it is very transparent. These material properties combined resemble glass quite well. To get a similar curvature, the process of vacuum forming is used.
Vacuum forming is a production method where a sheet of plastic is heated to a state where it would start to flow and can be moulded. When the flowing temperature for polyester is reached the plastic is placed on a single-surface mould. From this point, the air in between the mould and the plastic will be removed and the plastic will start to take the shape of the mould.
So, before the double curved glass can be created a mould is needed. To realize this mould, first, a parametric mould design is made using Rhino 7 and Grasshopper. This process is briefly described below.

The first step is making a surface in Rhino, and dividing it into about 9 parts. This creates control points that are used to deform the surface. After a desirable shape is achieved, the surface is then loaded into Grasshopper. As a first step, some more flat surfaces are attached to the boundary edges of the curved surface. This is needed to create a surface where the glass can be easily connected to the spiders. Next, a script divides this surface into thin strips with a changeable thickness that will represent the thickness of the available wood. These strips are then extruded. The form of these strips is projected on a 2D layout.
To make the mould, the 2D layout is printed and glued to the wood as a saw drawing. After sawing all these parts with a jigsaw, the mould is created by using brats and glueing the multiple multiplex layers together. This mould is placed inside the vacuum machine. From this point onward the plastic can be heated and pushed over the mould. After the process is done the panels are trimmed a bit and are ready to be attached.

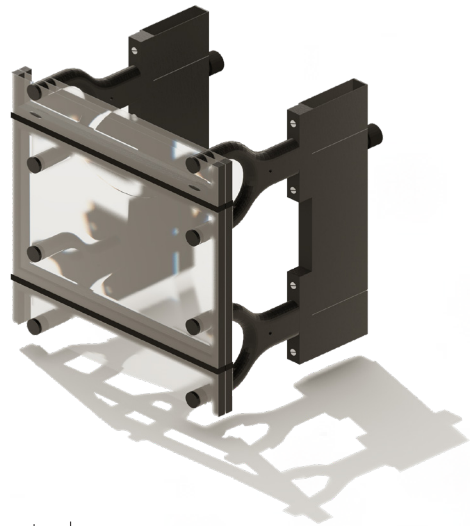


Scaling to prototype - Storage

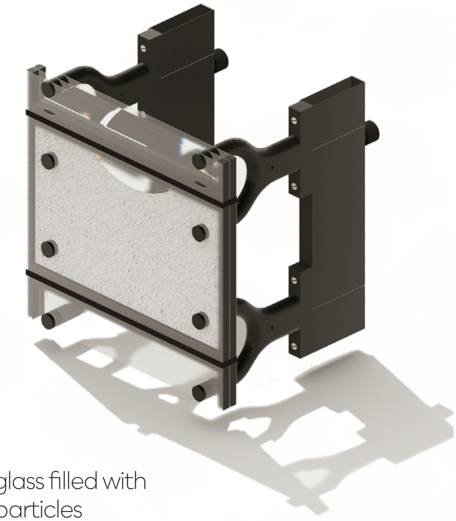
In order to make the storage, instead of aluminium wood is used. This is because wood is easy to work with and was also made available during the building weeks. The material also corresponds with the material of the spiders. The size of the storage has been chosen based on the height of the prototype, therefore it will not exceed 60cm. To make the storage, a track saw for the longer and bigger parts and a table saw for the smaller parts and halving the bigger pieces will be used.

For the static electricity, chicken wire is lied in the storage and grounded through a ground wire that is plugged in.
To connect the vacuum, a sock will be used as a filter on the hose of the vacuum and the hose will then be shoved in inside the back part of the storage, where a hole should be made in the size of the hose.

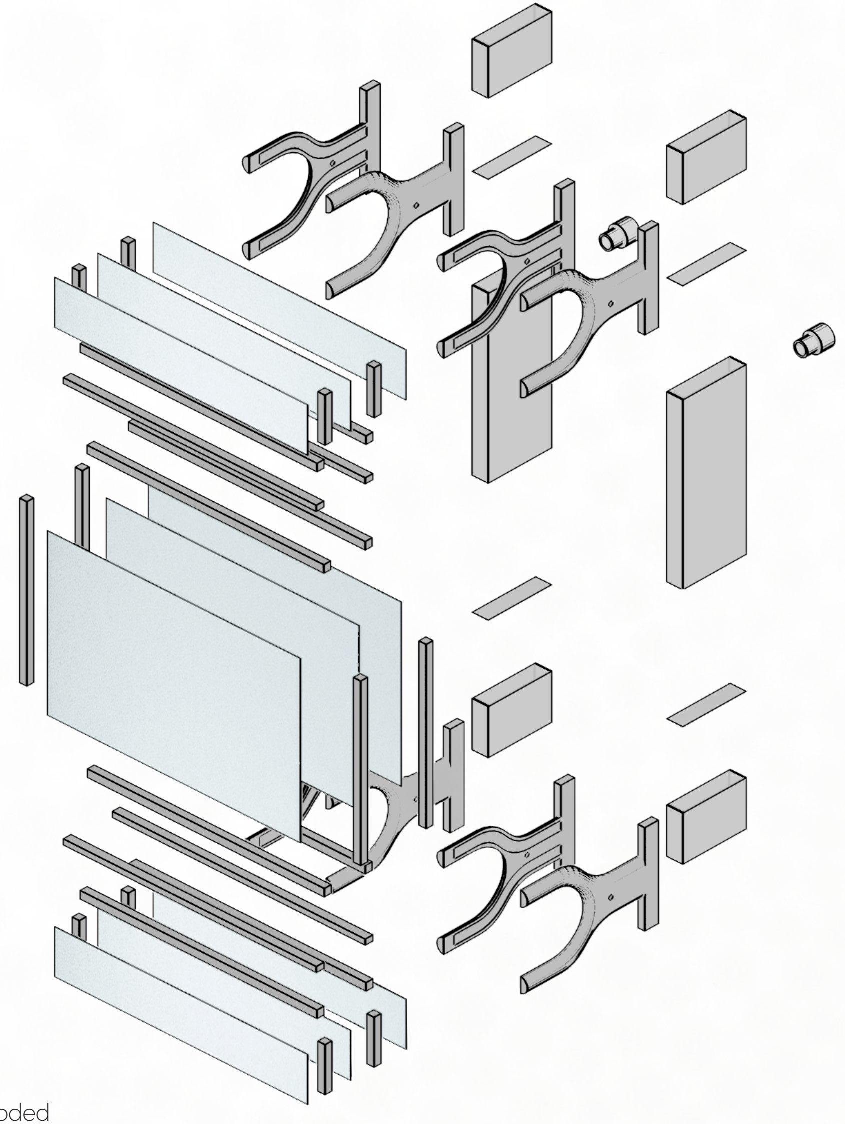
3D Visualization prototype



empty glass



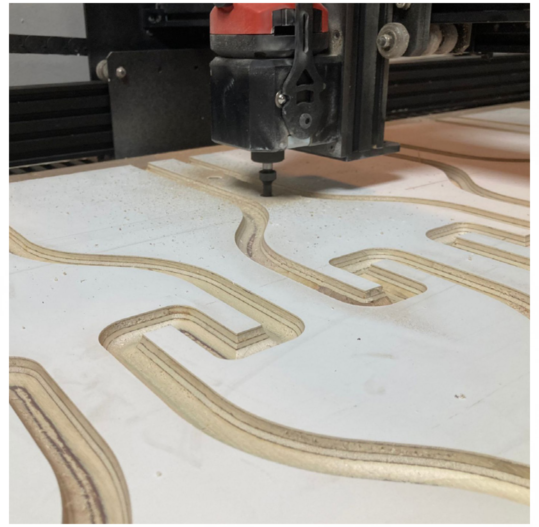
glass filled with particles



exploded axonometry

building weeks

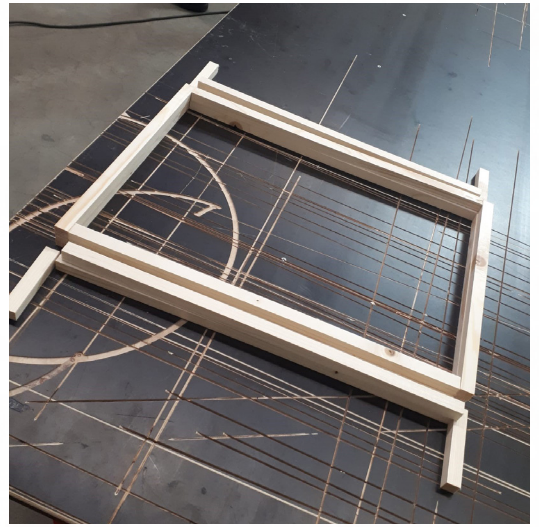
Building process


CNC machining the wooden spiders


Sanding the spiders

Assembling the spiders with screws

Sawing the wooden spacers for inbetween the three layers of Vivak



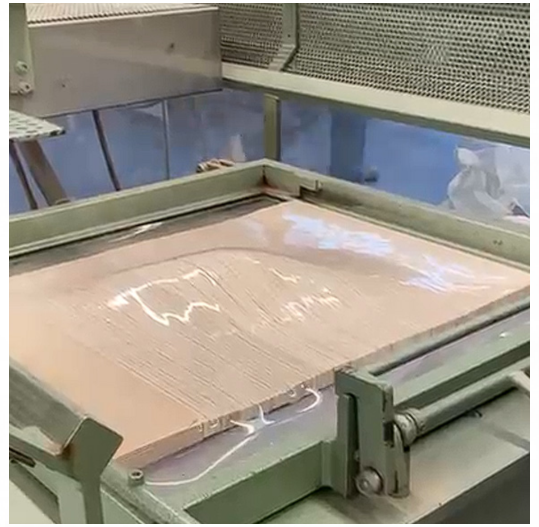
Checking if the dimensions are correct

Attaching double sided tape on two opposite sides

Sawing the individual pieces of the wooden mould with a jigsaw using the printed template

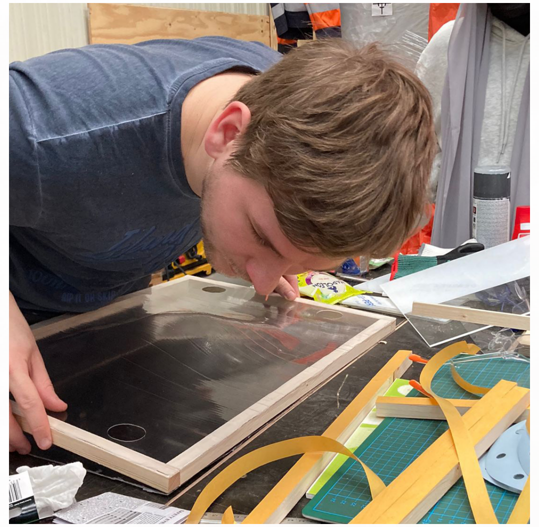
Bratting the pieces together to form two big pieces

Using domino's and woodglue to connect two big pieces



Vacuum forming three Vivak sheets with the mould

Sanding the mould to give it a smooth surface



Attaching the Vivak sheets to the pre-taped wooden spacers

Using the table saw to cut the wooden panels for the storages/ reservoirs to size

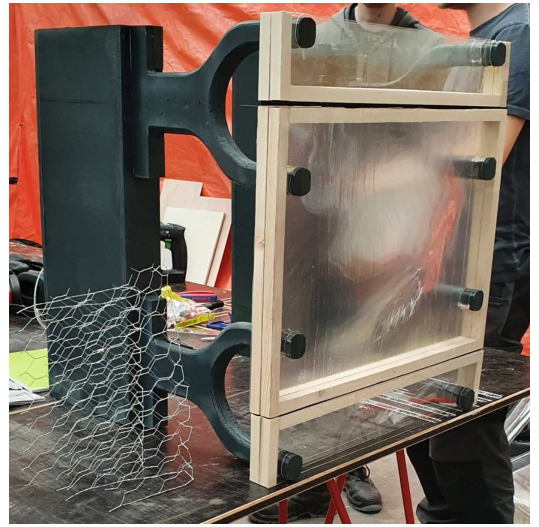
Assembling the storage and connecting it to the spiders

Adding chicken wire inside the storage and spraypainting the system

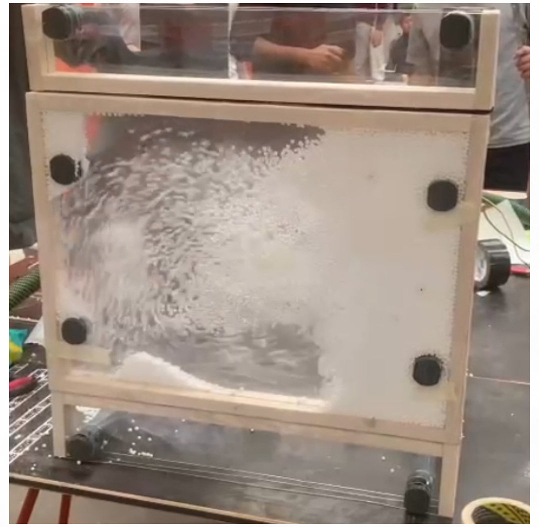
Filling the storage with EPS particles

After realizing the need for two vacuum cleaners because of the two separate storages, a PVC divider piece was used. Also, the hole for the vacuum cleaner hose wasn't airtight enough and the textile was blocking the air too much, so a sock was used as a filter instead

This bottlenecked the system, so a PVC tube was inserted inside of the storage. In this tube, holes were drilled to divide all the suction or compression power.



Hanging the frames on the spiders



Attaching the vacuum cleaner and running the first tests

After some discussion it was decided to revert the storages to their original color and to add a perspex panel to be able to look into the storage. During the test, immediately some problems occured, which are described in the next part

In this paragraph the problems that occurred in the prototype are briefly described. A lot of improvements to the system were made during the later days of the building week to solve some of these problems. These solutions are also mentioned here.

The cavity doesn't fill or empty completely
Rotating the entire system so the storage becomes horizontal creates a more even distribution of particles per spider, which results in a filled cavity. Also, fixing air leaks around the storage using tape helped to improve the airflow. However, not all leaks could be prevented. Adding on to this, the final product should have completely sealed connections between the glass and the spider. These could be 3d printed or milled and then a transparent kit could be used to completely seal it.
Other options to improve the system so it fills better were moving the vacuum port from the middle of the storage to the bottom. With the port at the bottom, pressurizing results in a filled cavity, but vacuuming works significantly worse than with a port in the middle. Finally, adding a port to the top of the store instead of the middle caused suction to empty the cavity better, however, using this port compression resulted in very mediocre results with a cavity that was only filled for one third.

The glass gets vacuumed when using suction
This problem was partially fixed by using brats to connect the Vivak more tightly to the wooden spacers, but the problem persisted. In a finished product, there need to be transparent spacers in between the glass layers so it won't deform when using suction or compression. However, these spacers also shouldn't obstruct the flow of particles in the cavity.

The storage bottlenecks at the output of the vacuum
We created a perforated PVC tube with a filter around it, which then was added inside the storage to spread the airflow. This helped to prevent the bottlenecking issue which resulted in more air pressure in the system when using compression and vice versa with suction.

The fact remains that buildings with irregularly shaped facades have little to no sun shading options. But is Parshade a good sunshading system for these types of buildings?

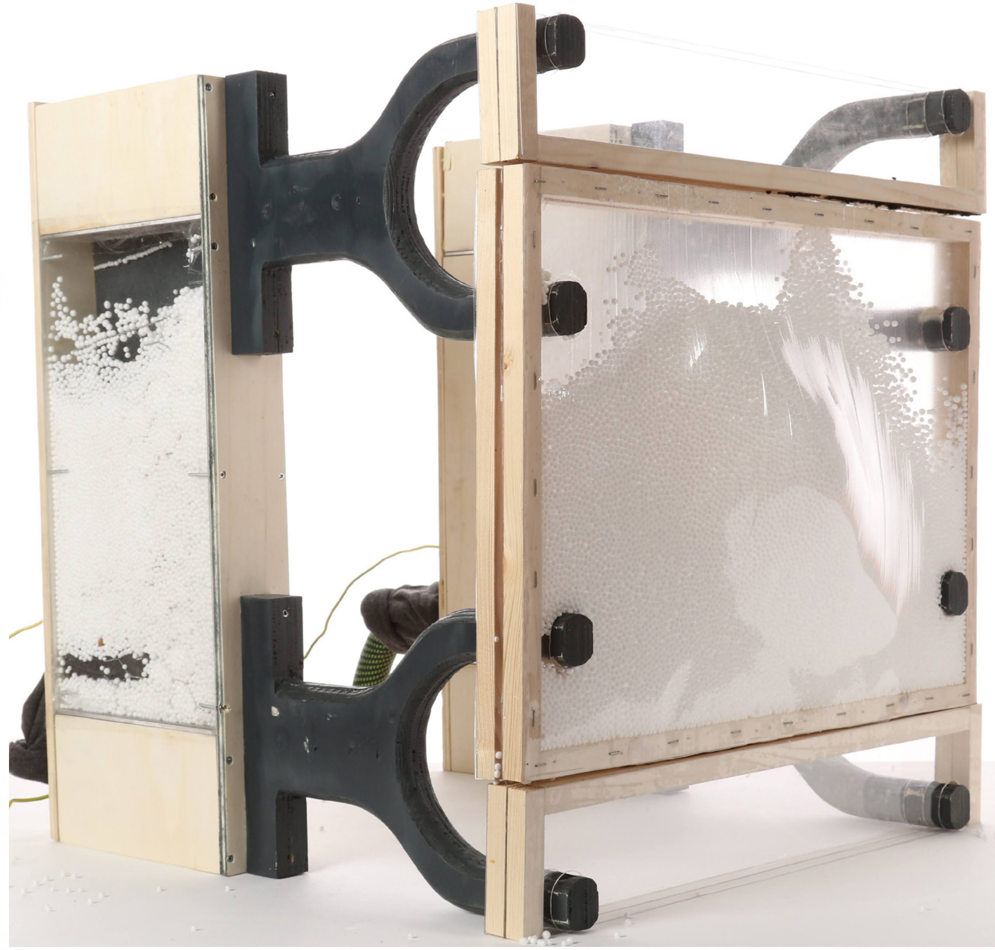
One of the most important conclusions that can be drawn from testing the prototype is the rapid deployment of the sun shading system. It works way quicker than anticipated: the cavity is filled in only a few seconds. Furthermore, the goal of making a completely invisible sun shading system when it's opened was also reached. As expected, the system also has a very unique way of closing and opening. During the building weeks, this really grabbed people's attention.
An aspiration a lot of architects have that's often paired with unique types of building designs is the aspiration for completely transparent facades. Parshade has proven to cater perfectly to this ambition. Other than that, the unique appearance of the shade also can be utilized in buildings with more public functions as a way to attract or impress visitors. So, all in all, Parshade has proven to have a lot of potential to serve unique buildings with irregularly shaped facades.

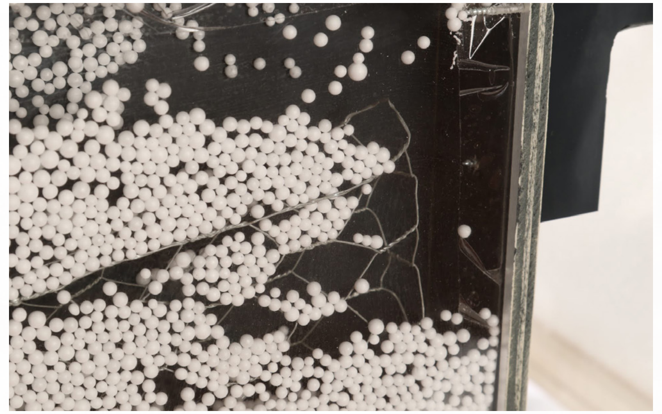
However, even though the prototype currently works and has a lot of positive properties, there are still a lot of problems that need fixing or improving. Before a product is designed that can truly fit the needs of the current market, a lot of future research is still needed to tackle these problems and to test bigger scaled models.

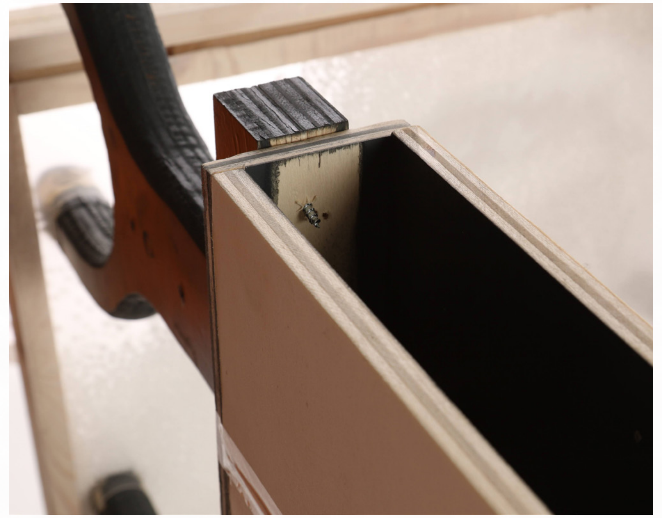
In the previous chapter, a couple of problems that occurred were already mentioned. Most of these problems were so drastic that they needed immediate improvement in order to make the prototype work. However, there are a lot of other topics for research that can be looked into to improve Parshade even further.

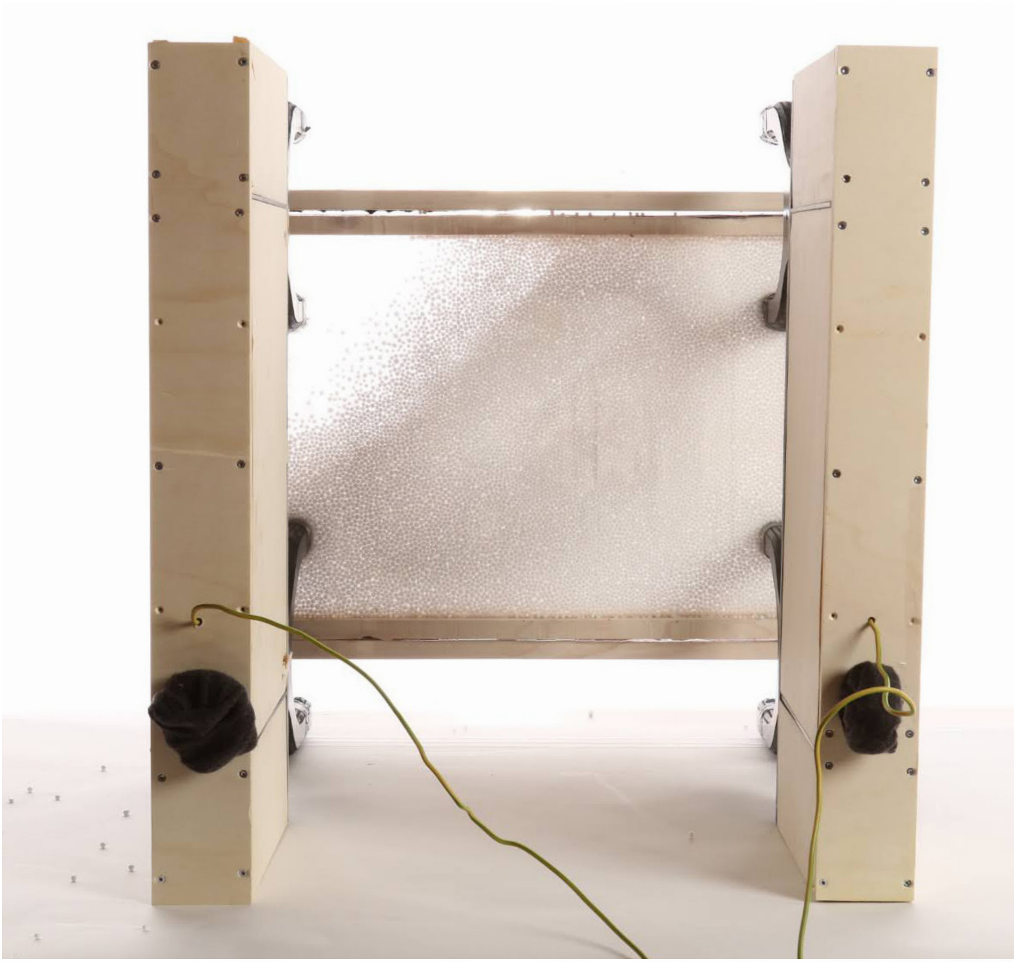
Perhaps one of the most important things to do consider is researching the context with glass instead of Vivak, where the curvature can be flat as well. As mentioned in the paragraph about problems and improvements, the first thing to test is whether spacers in between the glass layers are necessary. The cavity Parshade uses is bigger than a standard cavity and has to withstand suction and compression. The Vivak used in the prototype couldn't handle this, and normal or even hardened glass probably won't either. This needs to be tested, and if the strength of the glass isn't adequate, designs for spacers in between the glass layers need to be both made and researched.
Another one of the area's that can be researched even further is the choice of materials for the particles. A lot of theoretical research into this subject is already done, but more hands on testing will deliver useful results that can be used to actually prove which material is the most fitting. Also, this can be researched in order to come up with a list of options that all cater to different demands in both color and g-value of the sunshade.
Directly correlated to this topic is the ambition to ensure static electricity doesn't occur anywhere in the system. This namely isn't a problem for all kinds of materials. However, for materials that suffer from static electricity, such as styrofoam, better solutions need to be found than the current chicken wire. One solution can be that instead of putting metal in the storage, an aluminium foil cover the inside of the spiders. This way all particles can come in contact with metal so they can give off their positive load.
A different topic that can drastically improve the functionality of Parshade is the location and orientation of the inlet where the compressor or vacuum is connected. During the building weeks it turned out that gravity was withholding a lot of the particles from entering the spiders, causing the cavity of the panel not to fill completely. By optimizing the air inlets this problem can be circumvented.

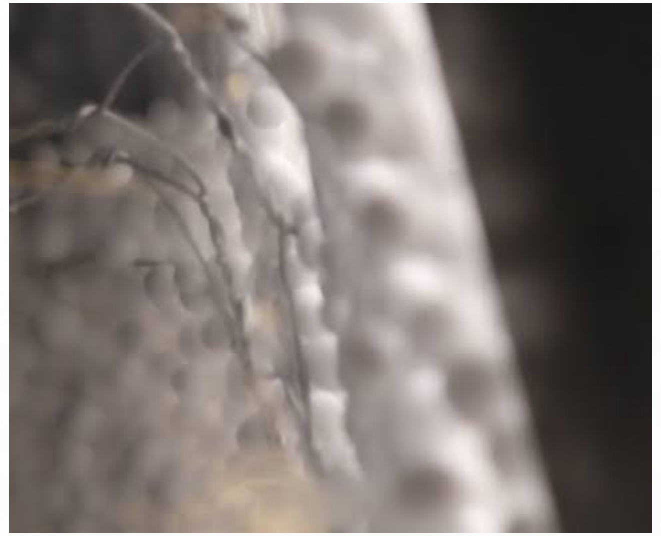
As is clear, there is a lot of research to be done. Yet still, the most important one of them all hasn't been mentioned: the making and testing of a full-scale model. After thoroughly researching all these subjects on such a scale, only then conclusions can be drawn whether Parshade truly is a product that fits the current or future market.









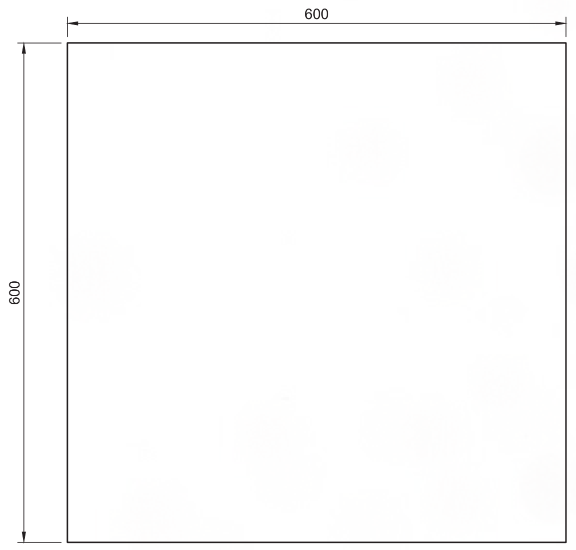


constructional drawings

Prototype Drawings | Cutting overview 1:20

Perspex parts

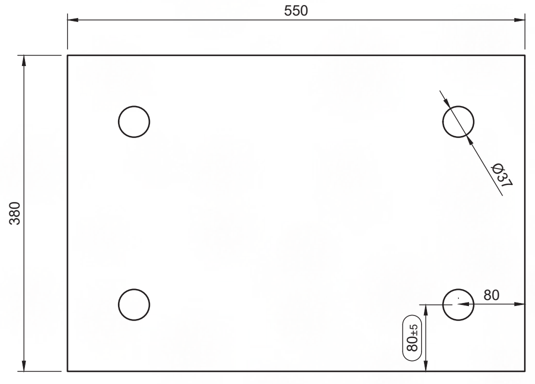
stock material: perspex 1,5 mm thick



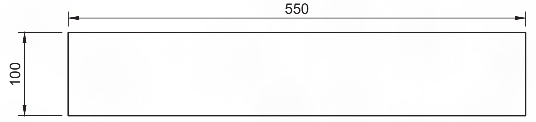
X3

vacuum formed material from stock shown above perspex 1,5 mm thick

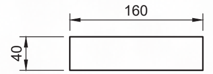
height of the hole should be checked whe the spiders are assembled



X3

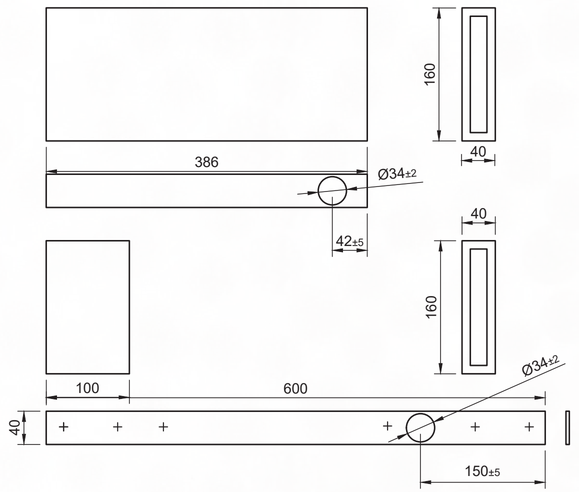


X6



X4

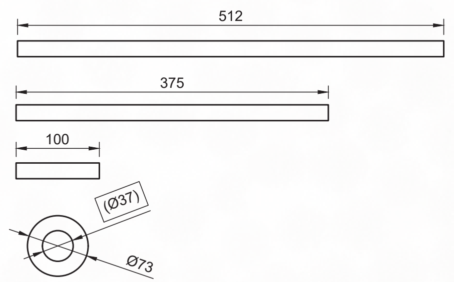
Aluminium parts



X2

X4

Wood parts



X8

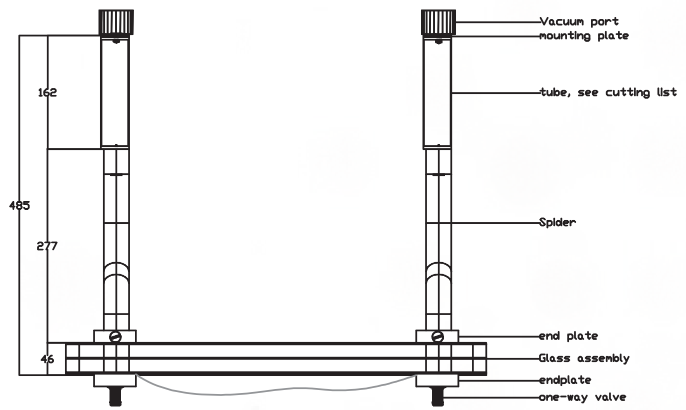
X4

X4

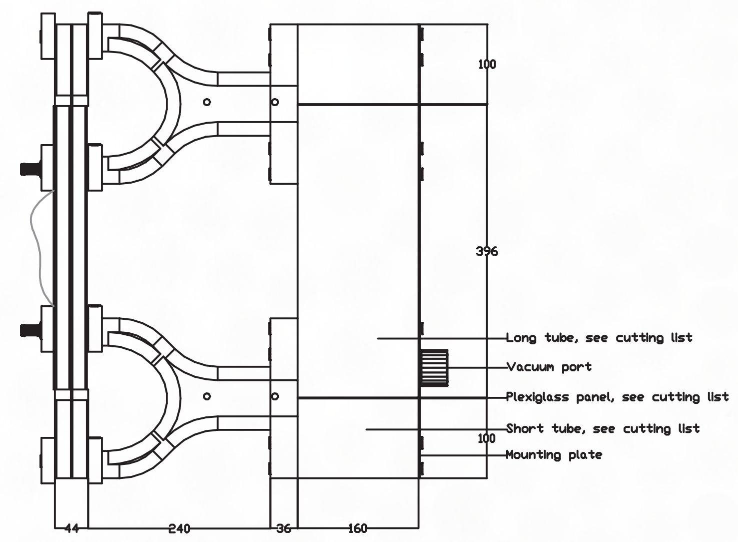
X16

Prototype Drawings | Elevations 1:10

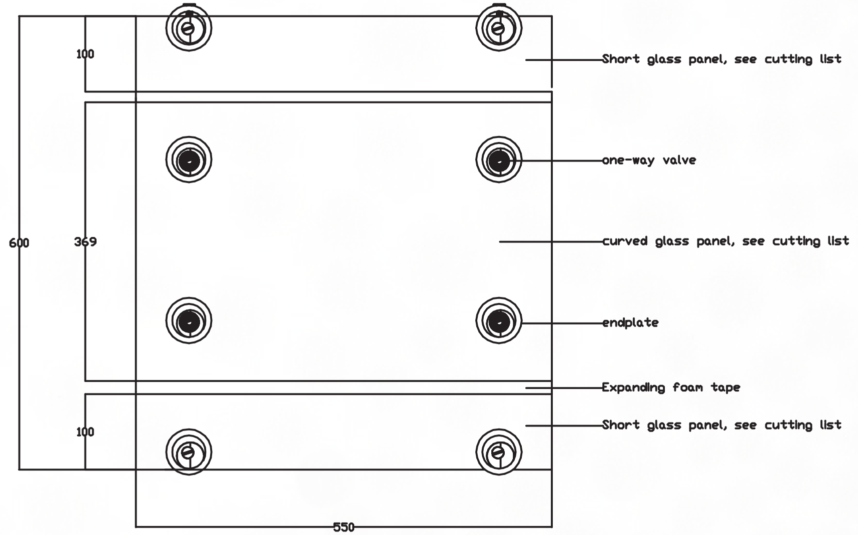
Top view



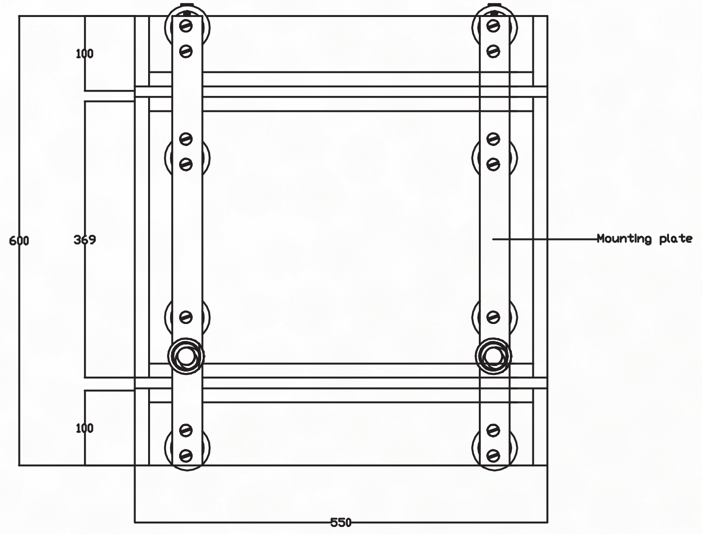
Side view

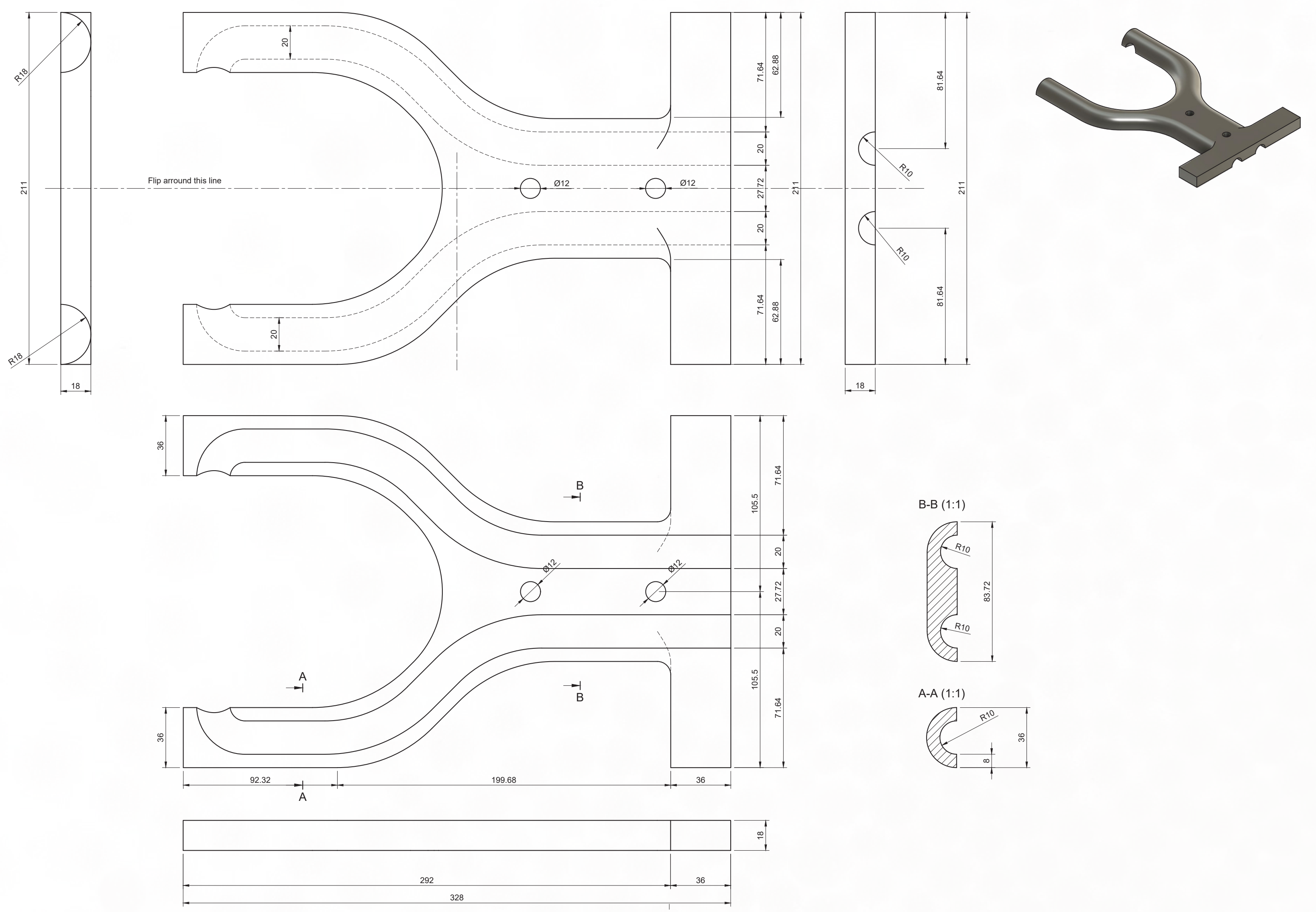


Front view



Back view





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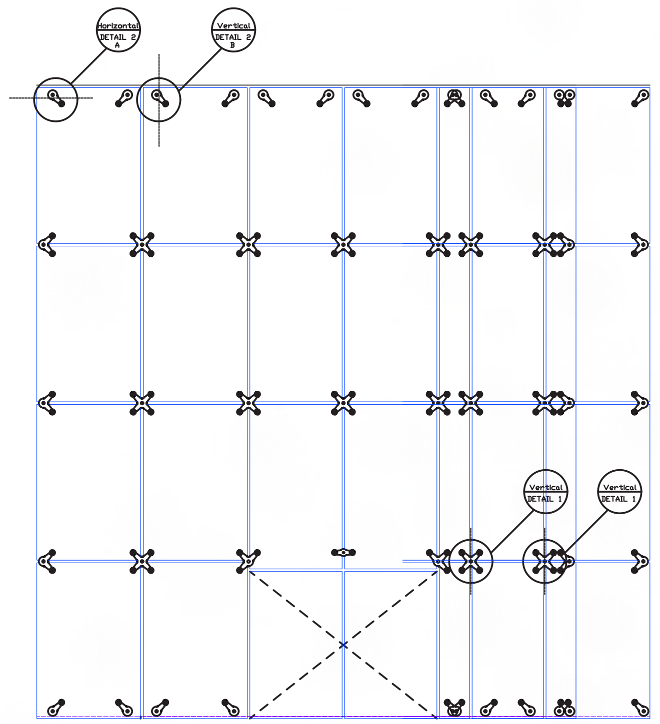
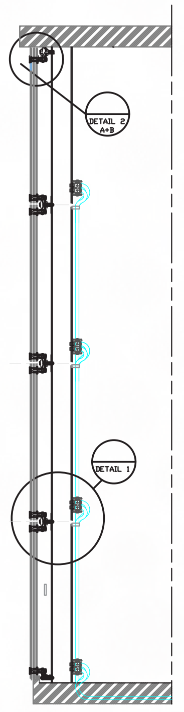
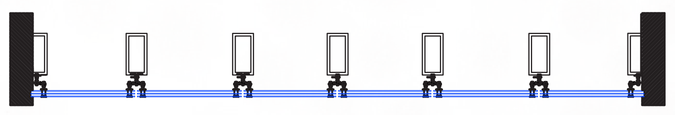


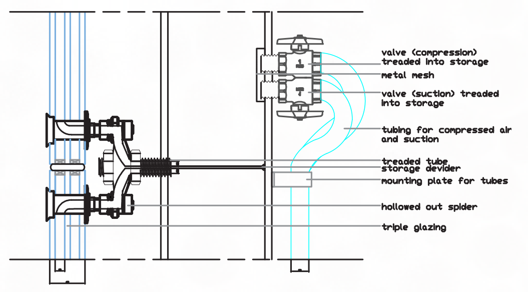
Side view



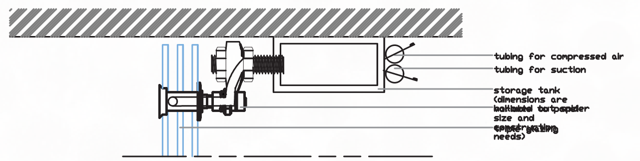
Top view



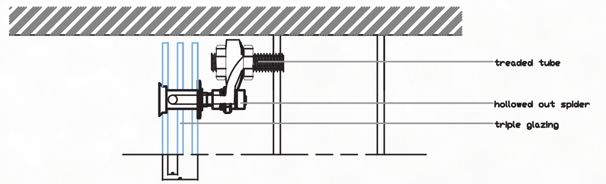
Detail 1



Detail 2



Detail 3



individual reflection

Personally, Bucky Lab has introduced me to a lot of things that I was never exposed to. Coming from a more academic and engineering background, I had never had the opportunity to get practical experience in terms of how things are made besides only thinking about whether it's makeable. With Bucky Lab, we had to go one step further and make sure it was buildable by ourselves, with limited tools. During the building weeks, I even used specific tools for the first time in my life. The entire day of introduction before starting to build was therefore very beneficial for me.

Apart from that, over the course of the designing process of Bucky Lab, we were able to implement knowledge and skills that we obtained with the courses that ran simultaneously. An example of this was using Edupack for the material choice. If I have to be blunt, I really like to realize that sometimes the things we learn at school, aren't the greatest tools to be used in practice. For example, during the material choice process, we realized that Edupack wasn't the greatest as it was not really meant to be used for an innovative product design process. That's where I realized that Edupack is great for when you have technical requirements, but not so great when you are seeking new materials. So, for this project, Edupack is great for the spider material choice, but not for the particles, as it did not take new materials or obtainable (by students) materials into consideration. We had to do this manually in the end.

What I really enjoyed was working in such an interdisciplinary team where everyone has their own strengths with preferences. What was for example very boring and bothersome work for one of us, was for the other one their favourite kind of work. This way we complemented each other well on our shortcomings and preferences throughout the design process.

Eda Akaltun

To start of, I think it was really nice to for once get to think out of the box and to actually realize your crazy idea's instead of resorting to standard products. In doing so however I must say that at some times, mostly in the beginning, it felt like we were making a product solely for the purpose of being new and different than standard sunshade options. Though the more and more we worked on it and came up with solutions that actually functioned greatly, the more I started to believe that our system is a viable product. In that sense, I feel like this process is perfectly described by the course name: I truly experienced it as if we were testing our product concept in a 'lab' to evaluate whether they were a mere novelty or actually had hidden potential.
To give a more personal reflection of what we could have done better as a team, in hindsight I think we could have done more calculations on topics such as the g-value of our system. Nevertheless, every week felt as if we made progress towards a working product, which was really enjoyable.

On a last note I would also like to point out how every member of our team had their own set of qualities, which helped tremendously when dividing tasks and made it possible for everybody to learn from each other. It also sometimes resulted in very different opinions which in turn caused some heated discussions. While at those times perhaps frustrating, I believe in the end it helped our group greatly because that way we investigated way more possibilities.

Oscar Chantrel

Bucky Lab Design has been an extremely important course in my academic career. In my bachelor's and my internship, I mostly designed residential buildings on a big scale: for this reason, this experience has been completely new to me. To be honest, I must say that at the beginning I was disoriented since I could not clearly see the "path", of this course. However, mostly during building weeks and, especially during the final presentations, I understood the great opportunity that Marcell and Nadia had given us.

Creating your prototypes with your own hands is something I've never done - except for cardboard maquette - creating and understanding every single detail after many visual and logical tries. Architecture and Engineering students are not used to this type of understanding functionality and spaces anymore because of the numerous software giving any kind of algorithm needed. We worked with specific machinery, materials and created our idea: a system made up of particles that through suction and compression gave life to an extremely innovative sun shading system.

For the realization of this project, I worked in an extremely homogeneous group: half having an architectural background, and the other engineering. I learned a lot from them and I hope I have left something to them as well. I believe in the potential of the prototype we have created and how it can have a consistent versatility in many respects; surely, our project proposal has never been realized before (and for that reason, I'm really proud), however, with any longer search times, I would have liked to find a more elegant and visible pleasing design that would have still fulfilled our goals and requirements.

Anyway, I thank Marcell and Nadia again for the opportunity given, and George and the other collaborators we met during the building weeks.

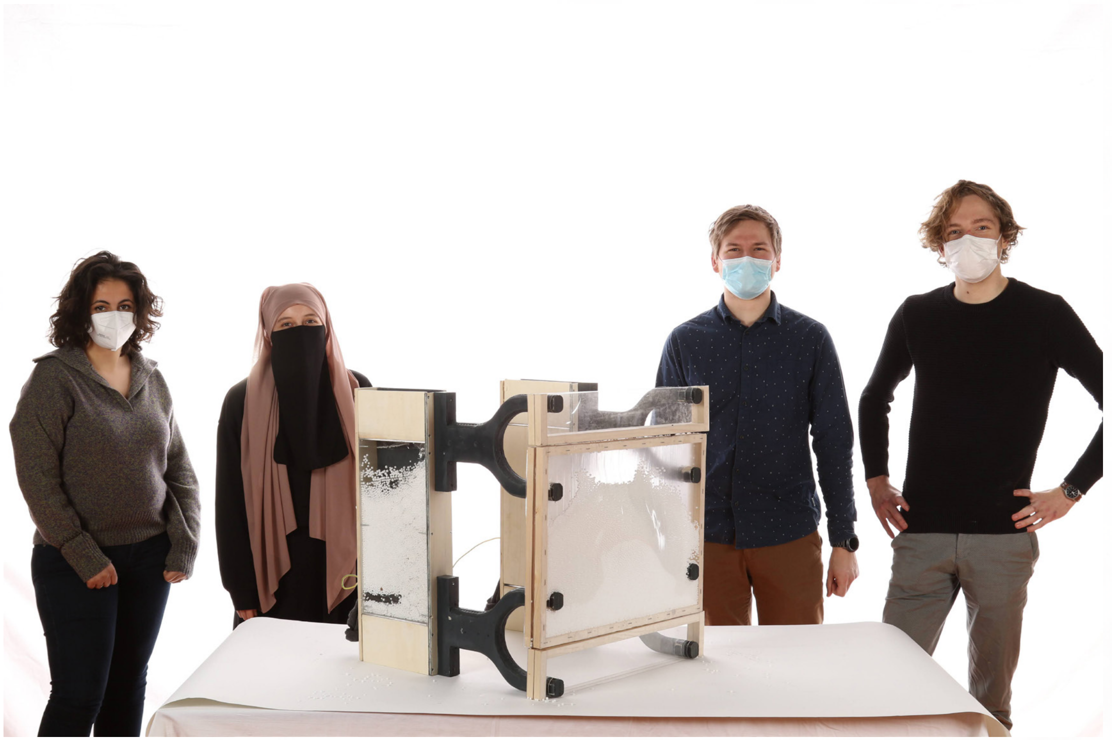
Laura Romano

Bucky lab has been a really interesting way of combining theoretical knowledge with some practical work. This part of the semester has been a time to relax and have fun in between the learning of all the other courses. Even though I had quite a bit of the same experience with my previous study there was always something new to be learned.

The building weeks were also a lot of fun. I have a lot of experience with woodworking and tools, and it was nice to give some of my experience to the other students. Besides that, I even could try some other tools. The first day was a bit bothersome, but after that, we got a good start with assembling our product. The results were astonishing.

We had a great team with different kinds/backgrounds of experience that would complement each other. I could not have wished for a better combination. We have learned a lot from each other and with the different kinds of interest, everybody could do what they liked.

Cedric Spijksma



BUCKY LAB