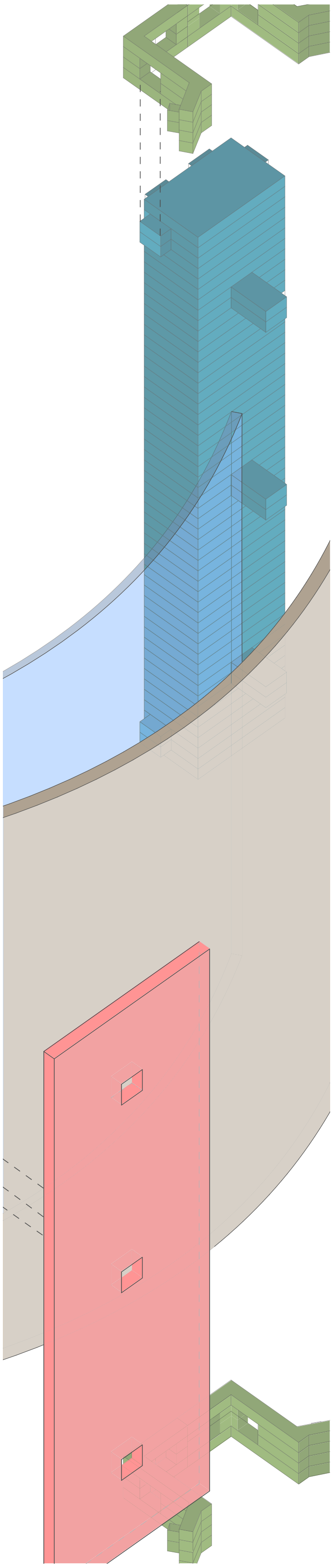
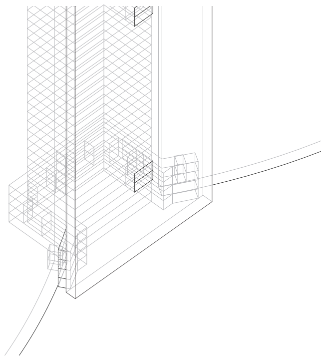
‘Plug-in’ Façade

Brandon Whitwell-Mak
Intermediate 12



AA Technical Studies, Materials
Tutor: Nina Tabink & Carolina Bartram
30th January 2014



Content

The Brief:

Most easily deconstructed (need to show complete system)
You must construct a piece of a facade min 30cm x 30cm for a temporary touring exhibition. The pieces need to be easy to assemble, demountable and easily transportable. Think of the key issues and what is the most suitable material and form.

At the end of term session we will test all the systems. You may need to bring drawings of joints etc. if you cannot model them. Points will also be added for innovative processes but points will be deducted for not thinking about the element as a true façade (for example if it does not provide insulation) and don't forget that this is an important visual part of your building.

My Response, short Thesis

The material this project investigates is sheet Medium-density fibreboard (MDF).

The investigation researches methods of transforming this rigid sheet material into a malleable and flexible sheet but to also retain some rigidity in order for an intelligent joint system (explained opposite and developed trough the research) to operate.

Although, this project looks at paper and MDF as materials, it can be viewed as the start of a wider project that has the potential to create 'plug-in' façades of this type on a large scale and with other fibrous materials, such as plywood, oak, teak, for example.

There are three main elements that form my 'Plug-in' Façade:

1. Sheet Material

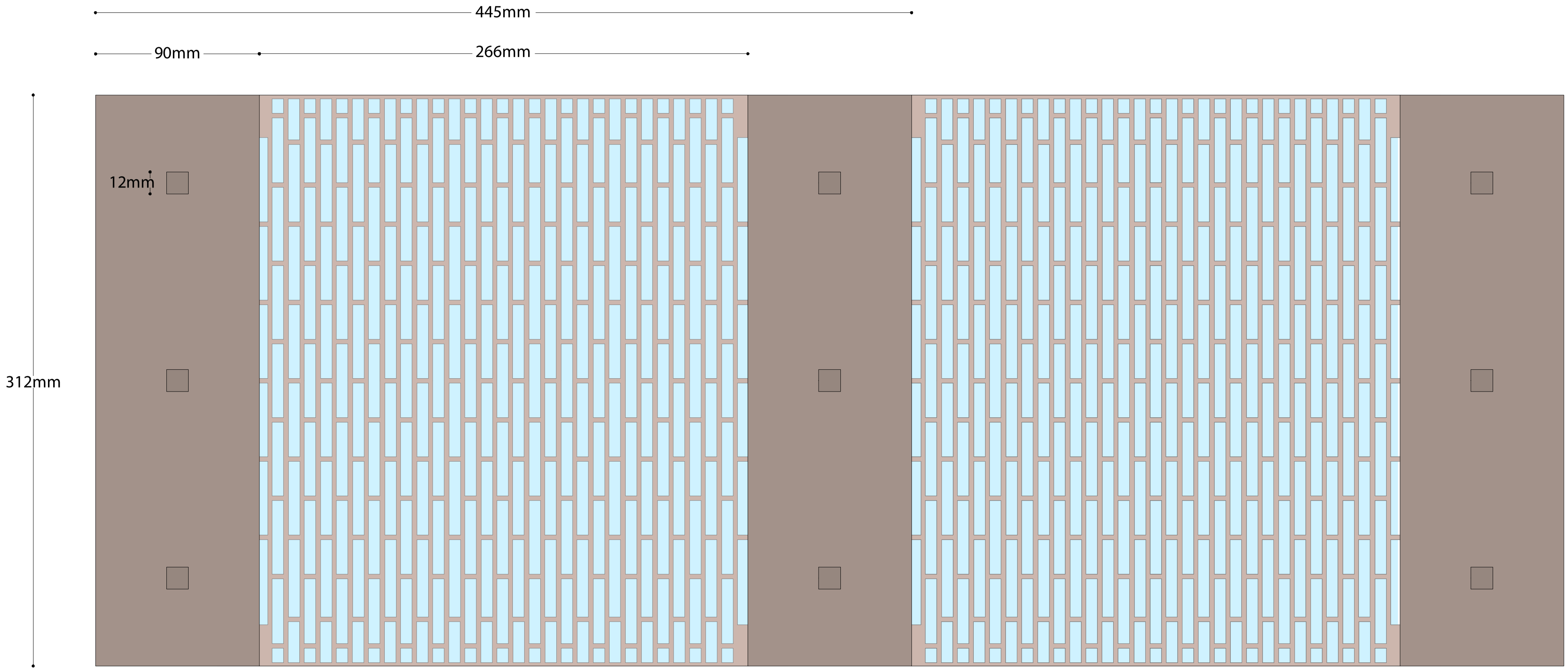
This is made from 3mm MDF and has been processed to decrease it rigid properties in order to make it flexible enable to be an integral art of the joint and assembly process. Material was removed in order for this property to work and therefore the sheet not only acts a joint system, but also a window element that allows light to filter through its frame.

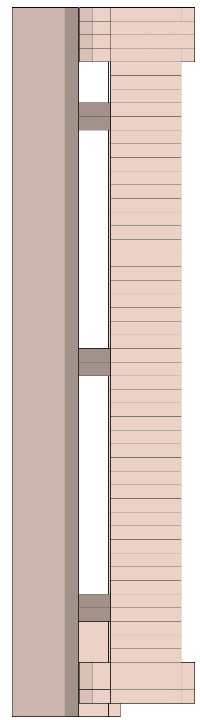
2. Joint

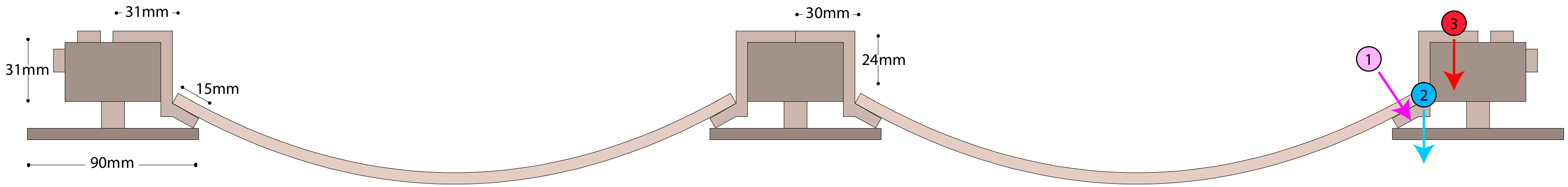
Natural forces generating from the elasticity of the manufactured flexible mdf creates a compressive force which the joint system utilises and connects with the column. This also means that the facade is easy to de-construct as one has to slightly flex the sheet to release it from the join.

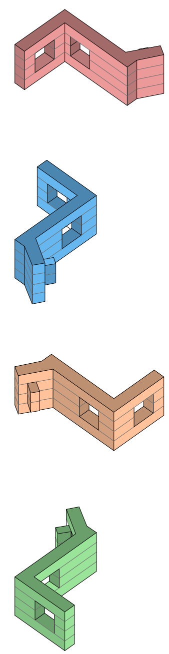
3. Column

The column distributes these forces to the horizontal plane, this might be the ground or another structural member.









1) The Rigidity of the flexible sheet material (MDF/Plywood) attempts to flex back to its flat surface. Thus allowing an opportunity for my 'plug-in system'

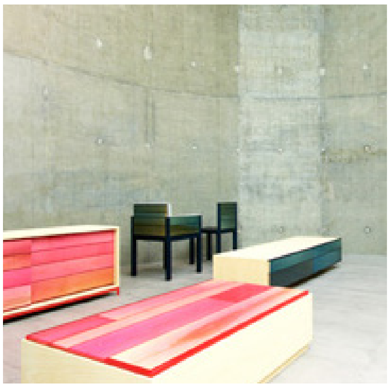
2) A clip attaches to the four corners of the flexible material and guides the compressive forces to the column

3) These Compressive forces allow a smart joint in which, the natural stress caused in the material is used to its benefit in connecting it to the joint and column.

Scale 1:2

0mm 60mm

Examples & Interest

JO NAGASAKA

Japanese architect Jo Nagasaka has developed a range of resin and wood furniture for Established & Sons.


KERF PAVILION
Brian Hoffer, Christopher Mackey, Tyler Crain, Dave Miranowski

The design of the pavilion is the result of an old technique reinvented using digital strategies and tools. Kerfing, the cutting of wood to add flexibility, has a long history in wood working.

Our research combined the material logic of kerfing with the flexibility of parametric modeling and the accuracy of a CNC router. Our parametric model integrated all the digital steps in the modeling and fabrication process, from initial control over the global form to the unrolling and generation of the cut patterns required to make each unit.

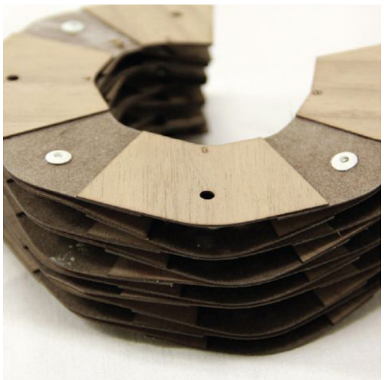
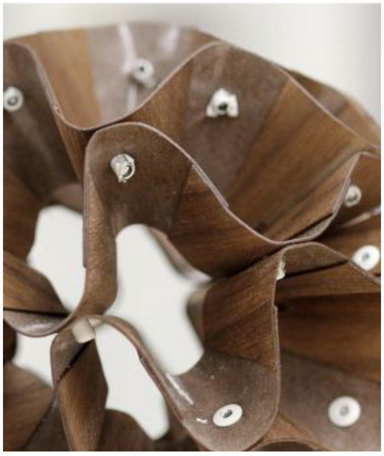
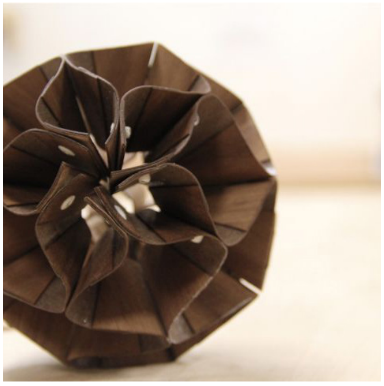
The patterns allow the plywood to be bent into a predictable shape without the use of additional tools or techniques.The pavilion is a manifestation of new possibilities for design and construction.

MIT Architecture
http://architecture.mit.edu/architectural-design/project/kerf-pavilion

Carbon Curve

The research and construction of Carbon Curve investigates the opportunities provided by the differentiated material organisation found in natural systems and their application in architectural design using composite structures.

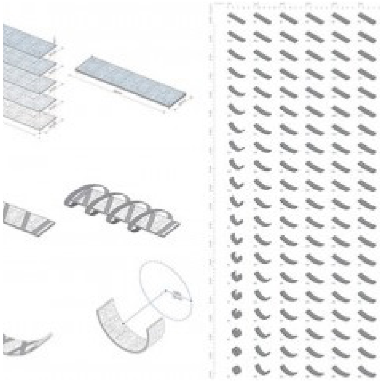
AA EMTECH
http://emtech.aaschool.ac.uk

RESPONSIVE EXPANSION
Sixto Cordero & Austin Smith

Although commonly considered problematic within the wider range of standardized isotropic construction materials, wood's mechanical deficiencies are simultaneously an asset for the adventurous designer. These anisotropic and organic characteristics can be critically investigated, even exaggerated, with the possibility of productively yielding a complex and adaptive building material.

MIT Architecture
http://architecture.mit.edu/architectural-design/project/responsive-expansion

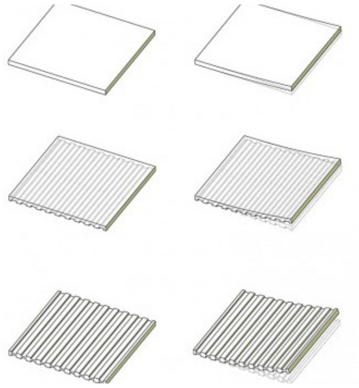


Arboreal Formations
Bartek Arendt, Chris Hill and Eleni Meladaki

Arboreal Formations is a research project that investigates how specific properties of wood may be a driver for curving pieces of timer. The thesis documents an approach for generating design solutions that capitalise on the investigation and understanding of wood's inherent properties.

A novel fabrication technique and understanding of materiality are combined through the research to conceive a timber component that can be programmed to create a range of curvatures and be structural depending upon its thickness. The innovation presents an opportunity for new architectural spaces and forms to be created in wood.

AA EMTECH
http://emtech.aaschool.ac.uk



Playwood
Yan Bai, Abhinav Champaneri, Miguel Rus, Nicolas Cabargas

The subject of our investigation is a material system that is capable of generating a continuous surface, which through material differentiation can incorporate aesthetically rich spaces, environmental responses and structural capacities. We focus our study on possibilities obtained in a material system derived by differentiated perforations in plywood. The prime aspect of the material system that we pursue is the variable flexibility that can be obtained within the plywood by strategic perforations.

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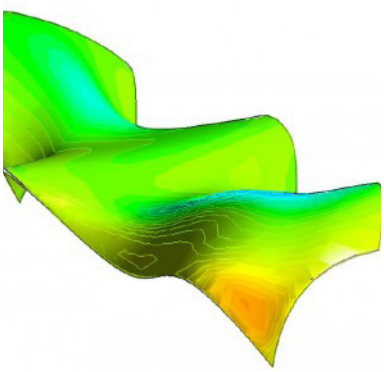


Miura Ori Folding
Napat Arunanondchai, Axel Koerner, Michela Musto, Prajish Vinayak

Taking inspiration from the hornbeam leaf geometry, our project explores with different approaches a system that could be able to combine flexibility to achieve a foldable structure and the stiffness that will allow the structure to be self supporting.

AA EMTECH
http://emtech.aaschool.ac.uk

AA-ETH Pavilion

In collaboration with the Chair of Structural Design at the ETH in Zurich, a temporary light timber construction was designed that functions as sun shading for parts of the grand stairs in front of the ETH architecture department.

AA EMTECH
http://emtech.aaschool.ac.uk

Experiment 1

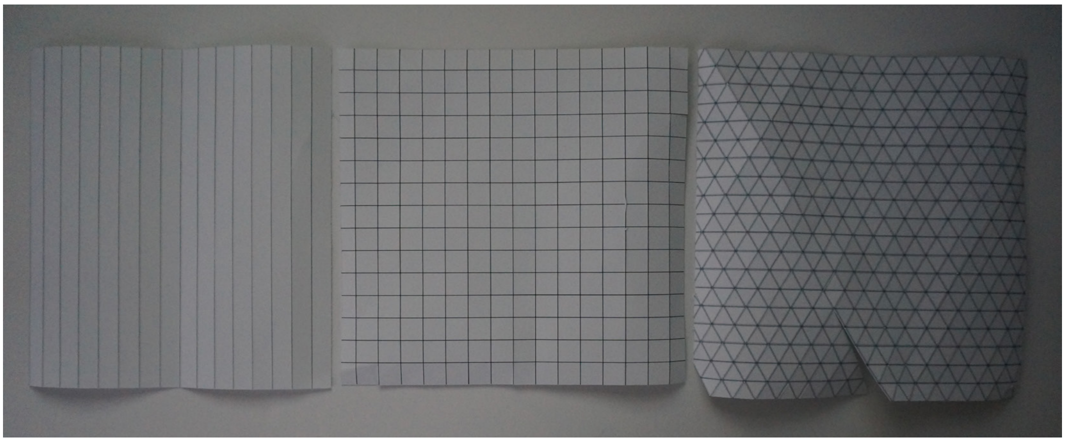
Material
100x100x0.2mm Paper

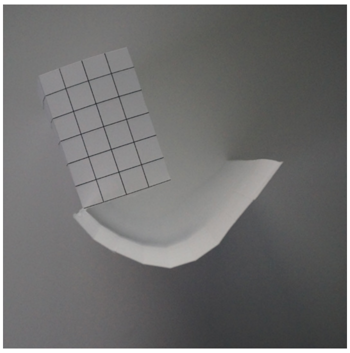
Aim
To understand techniques of increasing flexibility in fibrous sheet materials

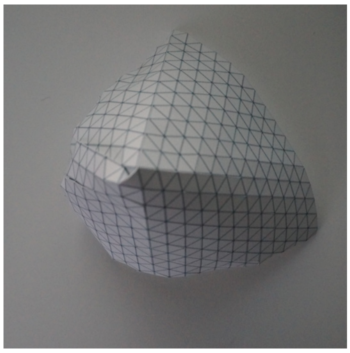
Method
Parallel, square grid score and triangulation scoring.

Result
Increasing depth and number of scores and varied direction increase the materials controllable.

Triangulation scoring is allows for more complex folding and curvature due to fibres in the material being controlled more by the triangular scores, compared to parallel and grid.







Experiment 2

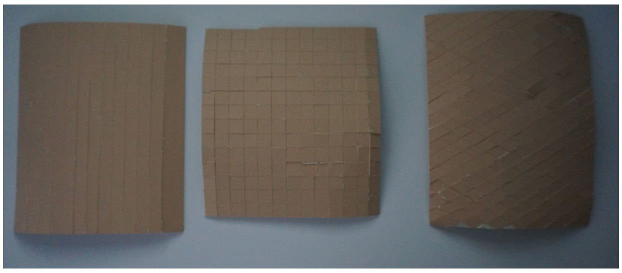
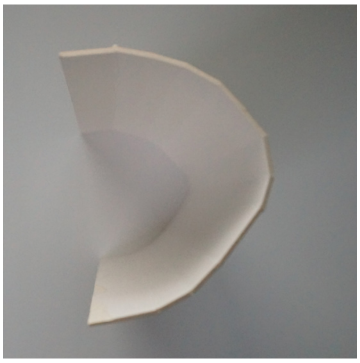
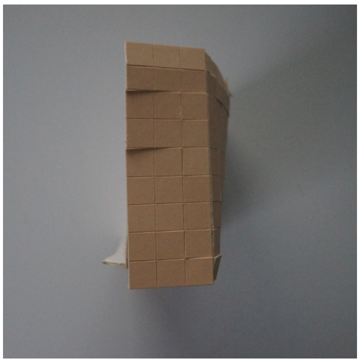
Material
100X100x1mm Card

Using the same Aim & Method as 'Experiment 1'

Result
The same result.

Due to thickness of the card, the depth of the score increases. Scoring needs to be more carefully manufactured, as depth of the score can create deeper cut in the material which allow for additional flexibility. The vice is also true, when the score is weak, the material responds weakly in flexibility.

The meeting of end points once the material is folded is an important consideration of the folded card. The joints have to take into consideration the material thickness, for a smooth and well fitted joint, in comparison to simply folding the paper and edges meeting easily due to its thin thickness.


Experiment 3

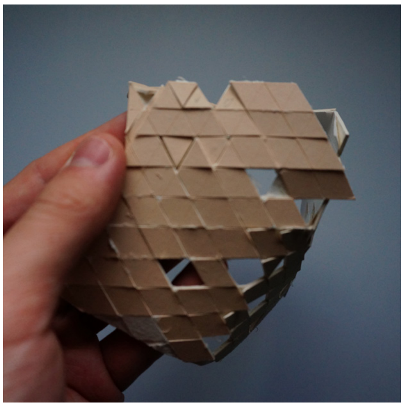
Material
100X100x1mm Card

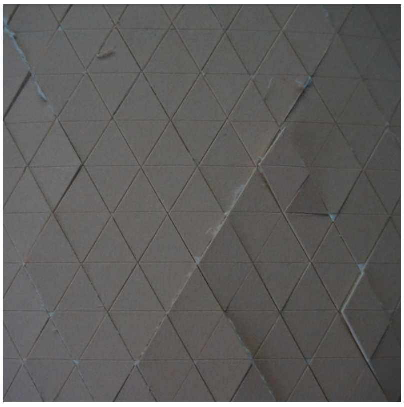
Aim
To understand forms and advantages of folding the card and incorporating a join system within the material and score.

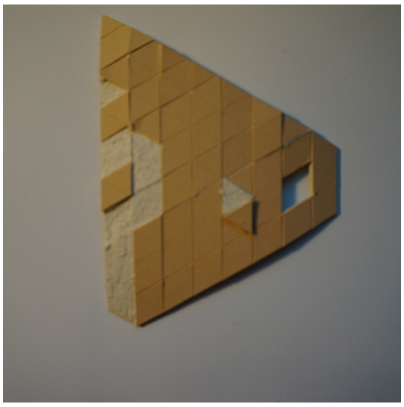
Manipulating the triangulation to utilise the amount of scoring for a requirement amount of folds or flexibility.

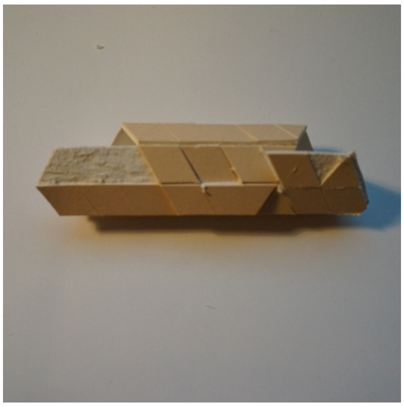
Result
The Removal of material created voids which could act as windows to allow light into a facade.

These voids also allow for integral 'butt' joint system to be created, as the material can be removed in thickness and slot within a thicker part, creating a advanced dowel joint.









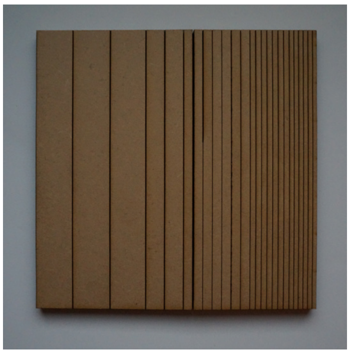
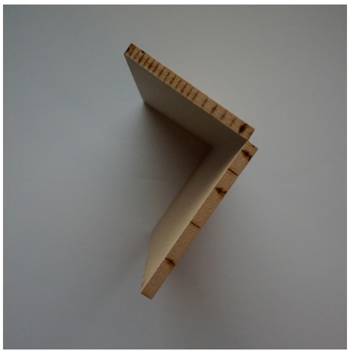
Experiment 4

Material
150X150x6mm MDF

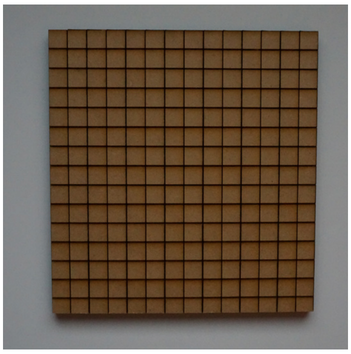
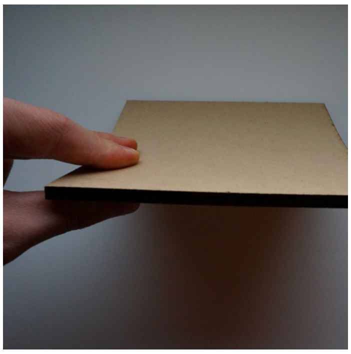
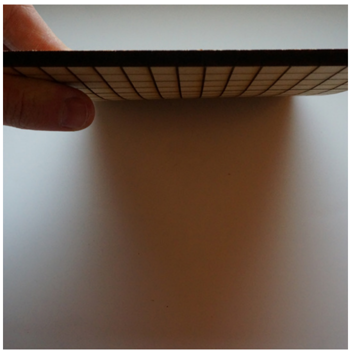
Aim
To understand forms and advantages of folding the card and incorporating a join system within the material and score.

Manipulating the triangulation to utilise the amount of scoring for a requirement amount of folds or flexibility.

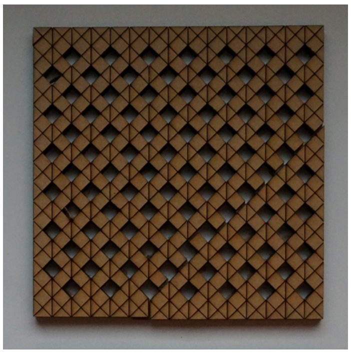
Result


Parallel Scoring : Material is rigid. The distance and depth of scores was not successful in allowing the material to flex. More material needs to be removed in specific locations as folds are possible, however, the Folds are possible, however durability of a score and fold would deteriorate over time.

Square Grid: More flexibility than the above. Curve can be created in either of the two axis. However this piece is not flexible enough to create a useful bend and the score also weakens the material.




Triangle Grid:

Triangulating the surface did not make the material very flexible. Very similar to the above.

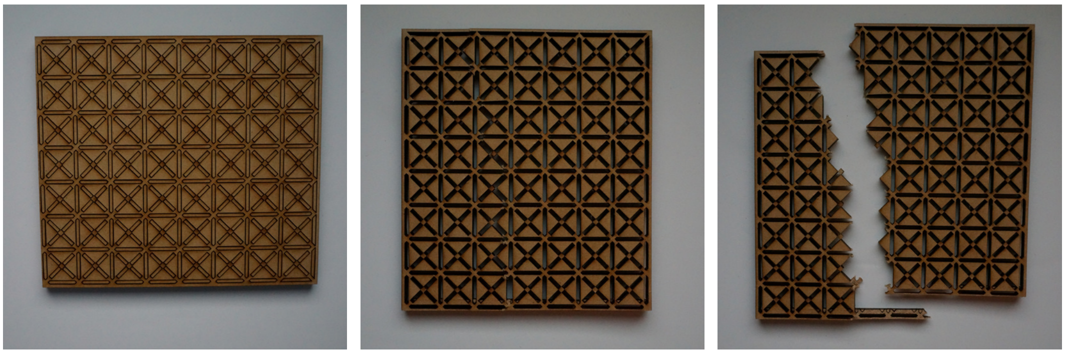
However, the joint system from Experiment 3 is tested here. A useful method of using the voids as a joint system and also window and ventilation potential.

Experiment 5

Material
150X150x6mm MDF

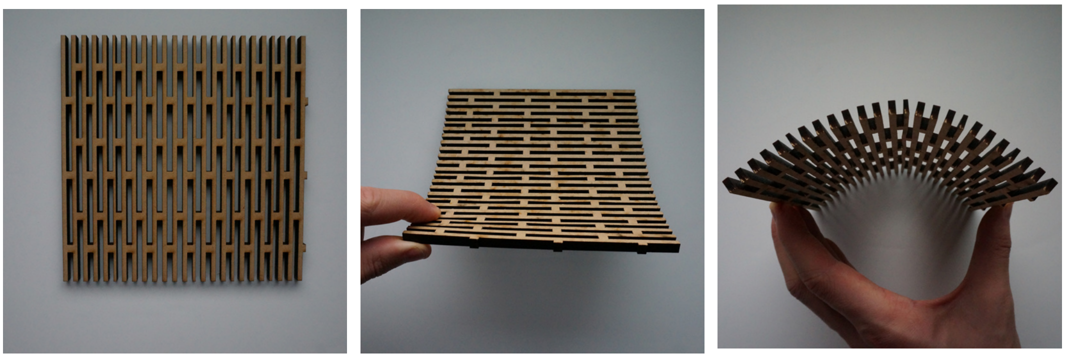
Aim
No longer scoring material, but removing material strategically to increase the flexibility of the sheet.

Result



Using the triangulation methods + Removing material:

A unsuccessful method which did not reduce the rigidity of the material. When force was applied to the fibres it caused the sheet to snap instead of distributing the load along the surface



Parallel strips removal of material:

Removing strips of material allowed the sheet to flex as the holes create space for the material to move and distribute the forces applied along its surface.

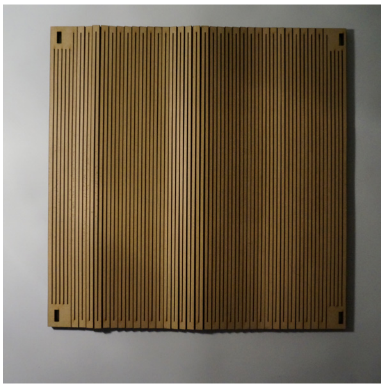
Additionally, the holes can be manipulated as windows, ventilation and also provide a facade which can flex and change easily.

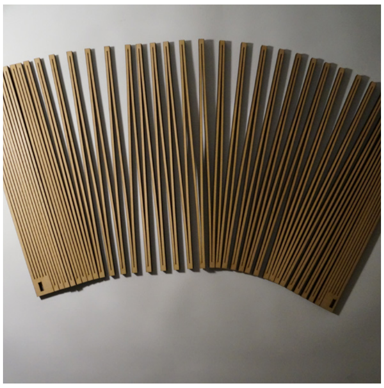
Experiment 6

Material
300X300x6mm MDF

Aim
Cutting Material, No removal of material

Result





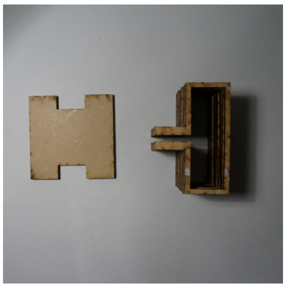
Cutting strips in the sheet reduced the rigidity of the material. This occurred due to the piece acting as lots of separate strips attached at the ends, thus allowing it to move when a force was applied.

However, this was too flexible, and not suitable for my type of facade. The piece needed a certain amount of rigidity in order to apply its own force on the joint.

Experiment 7

Material
150X150x6mm MDF

Aim
Looking at joint mechanisms



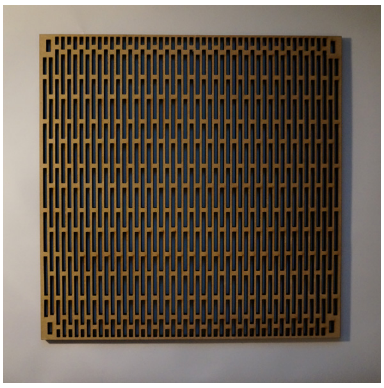
An unsuccessful joint mechanism. Attempt to 'plug-in' and turn which would lock the plate and allow for easy removal. However, it gave the base for further design development of a 'plug-in' joint later.

Experiment 8

Material
300X300x6mm MDF

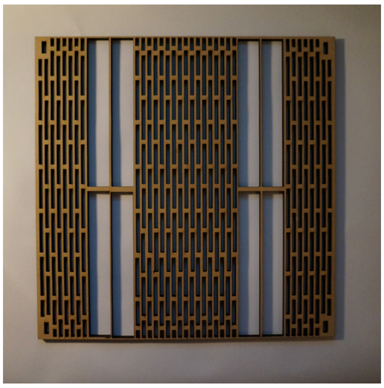
Aim
Testing the linear removal of material at 1:1 scale

Result



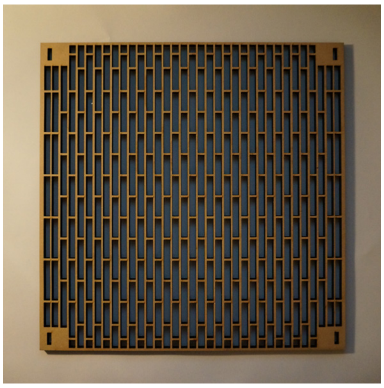
Copy of the same pattern as used in experiment 5. However, the result was not the same. This is due to the scale of the sheet being double that of experiment 5.

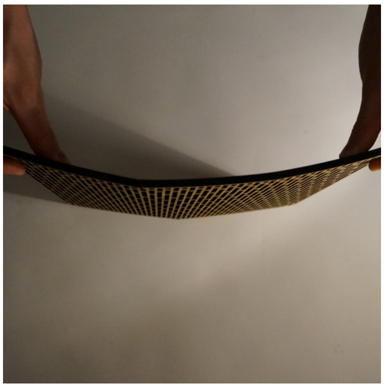
Additionally, if this was used as a facade pattern, the distribution of light would be very filtered. Therefore, the potential of expanding the gaps could bring a double benefit of lighting and flexibility.



This experiment shows an adaptation of the previous with larger voids which could allow more light into a facade.

However, they have a detrimental effect on the material strength, as it becomes very weak at the framing points and is not rigid or flexible.





The gaps in this sheet follow the same linear pattern as the above. However, the gap created is double that of the above. This was manufactured like this with the idea that due to the sheet being twice as large as the previous, then the void should also be twice as large.

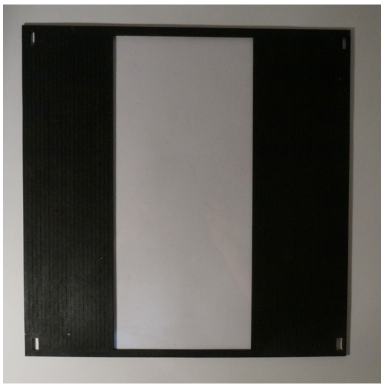
This change did allow for the material to flex more and also provide enough rigidity for my clipping system.

Experiment 9

Material
300X300x3mm MDF

Aim
Using the same linear pattern from Experiment 8, but with 3mm MDF to increase its flexibility slightly more.

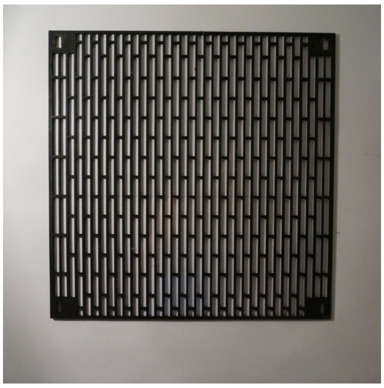
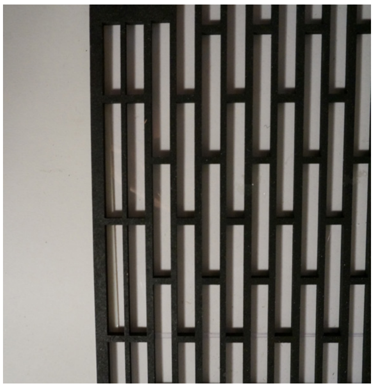
Result



The reduction in thickness of MDF allowed the material to become flexible and also have the rigidity that was needed for my 'plug-in' system to function.

The design above, shows a sheet that has been cut, as seen in experiment 6, however the cut does not exceed the frame, therefore allowing a contained rigidity due to the frame that holds the cut bits together.

Additionally, this allows for 30% of the sheet to be removed, allowing a void for light to enter the facade.

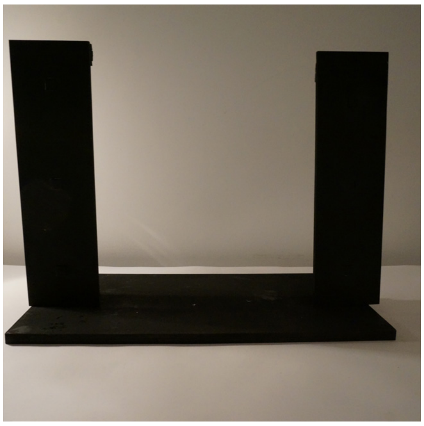
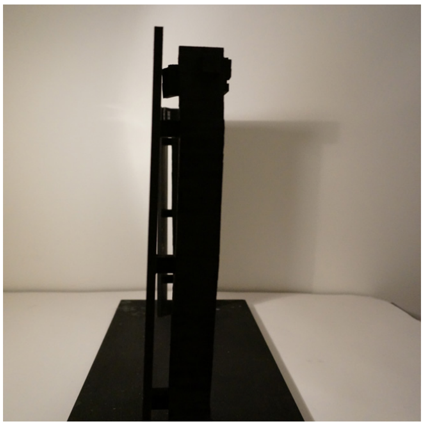
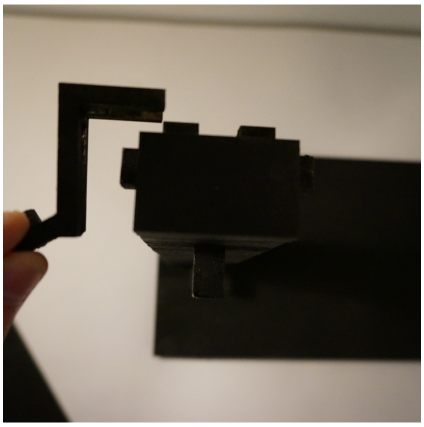
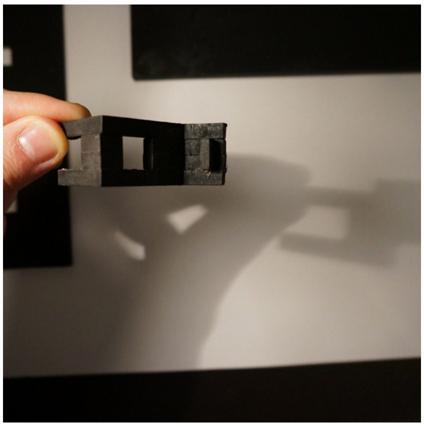
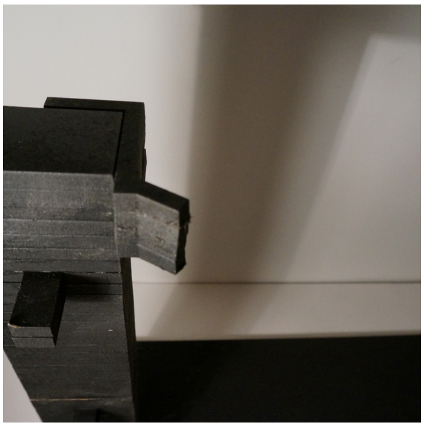
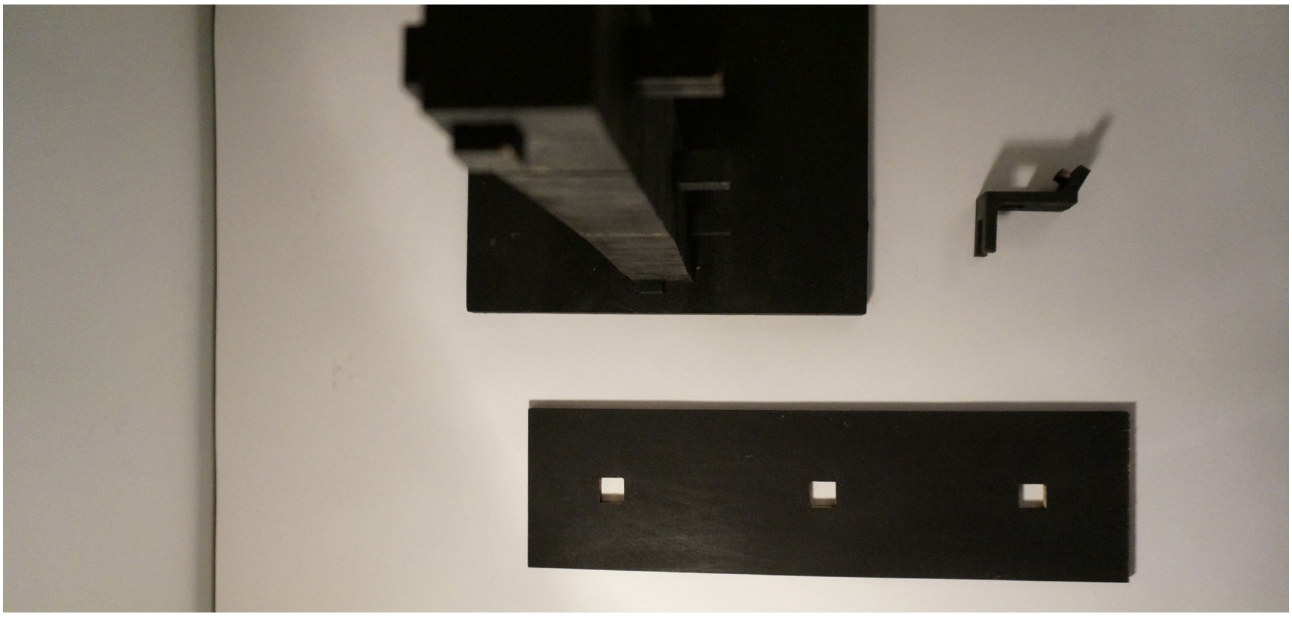

Again, the 3mm MDF allowed the sheet to retain its rigidity whilst also giving it a flexibility that was vital for my demountable facade to function. This is the same linear pattern as seen in experiment 8, that allows for light to filter into the facade. A layer of PVAc is glued to the behind of this piece and allows for protected transparency, acting as a window and a demountable part of a facade.

The Frame (See diagram, page 2)

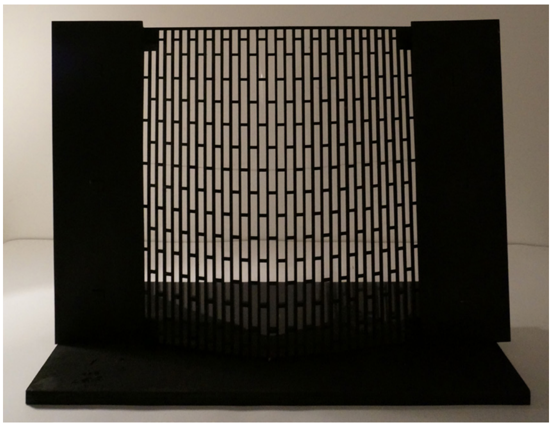
Material
300X300x3/6mm MDF

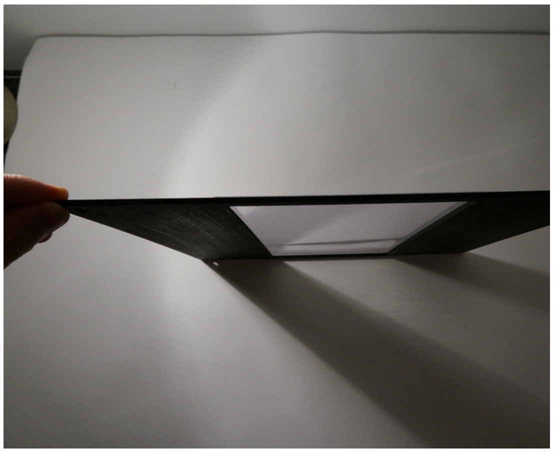
Aim
A demountable system that allows the 300x300x3mm facade pieces to bend, clip and hold. Addition of paint, give the MDF a layer of protection from weathering and other potential chemical reactions that could deteriorate its structure and material.

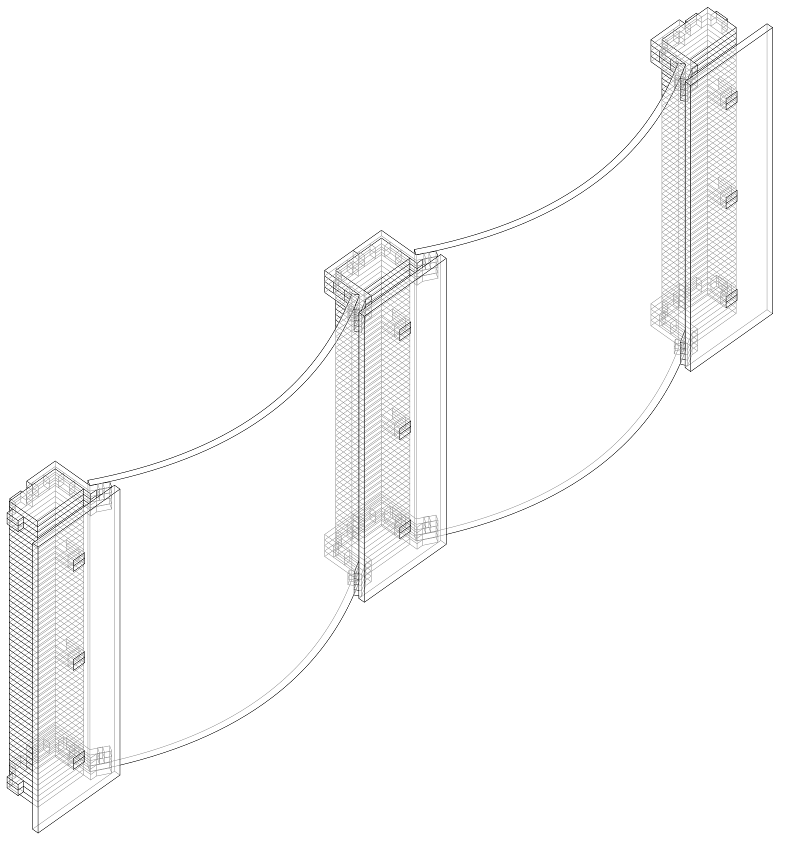
Result

The Façade



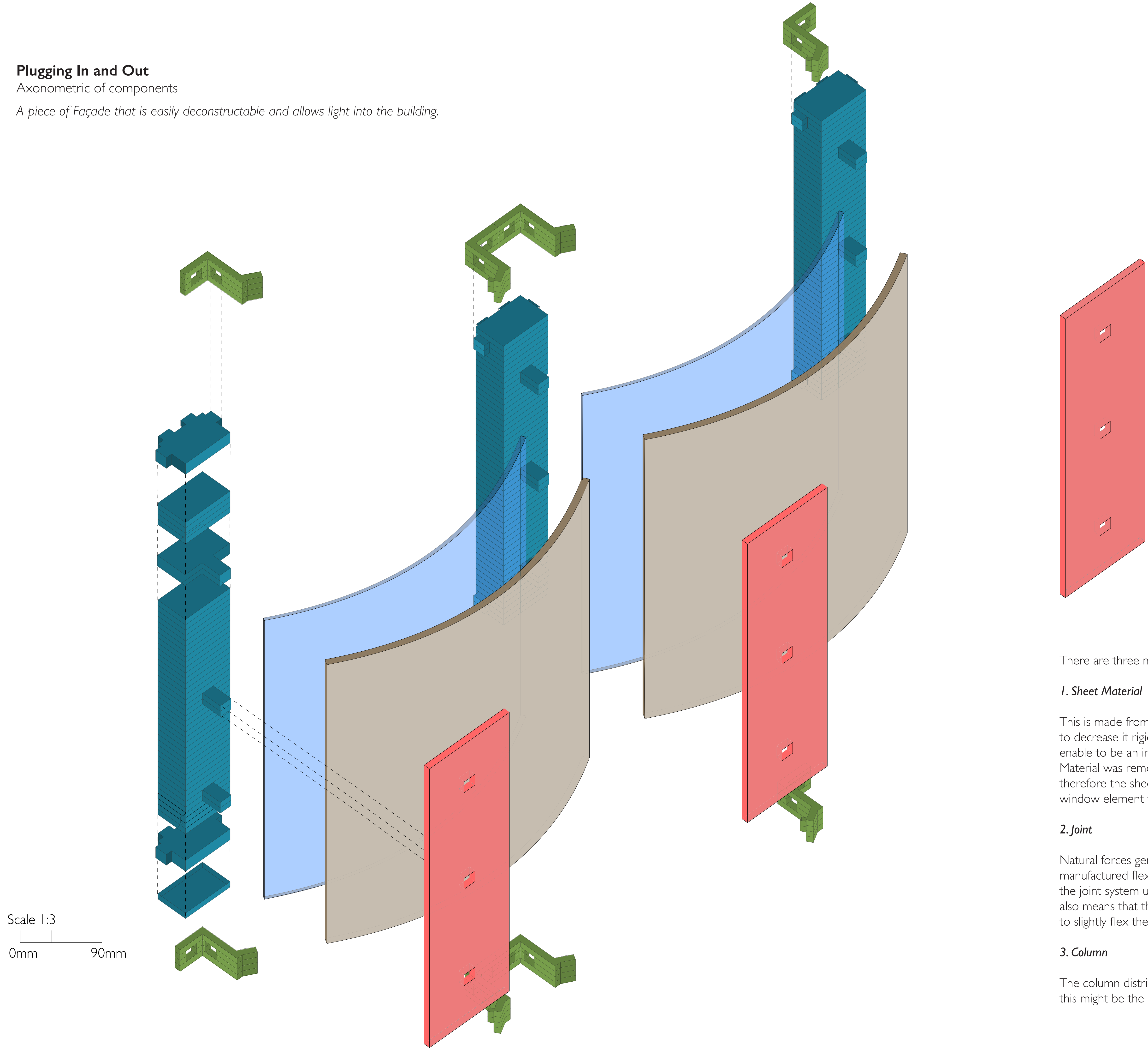




Plugging In and Out

Axonometric of components

A piece of Façade that is easily deconstructable and allows light into the building.



There are three main elements that form my 'Plug-in' Façade:

1. Sheet Material

This is made from 3mm MDF and has been processed to decrease it rigid properties in order to make it flexible enable to be an integral art of the joint and assembly process. Material was removed in order for this property to work and therefore the sheet not only acts a joint system, but also a window element that allows light to filter through its frame.

2. Joint

Natural forces generating from the elasticity of the manufactured flexible mdf creates a compressive force which the joint system utilises and connects with the column. This also means that the facade is easy to de-construct as one has to slightly flex the sheet to release it from the join.

3. Column

The column distributes these forces to the horizontal plane, this might be the ground or another structural member.