DYNAMIC FACADE SHADING

by

Erik van der Thiel
4045351
&
Johan Bogaart
4022416

MASTER OF BUILDING TECHNOLOGY

In the
Faculty of
Architecture

TECHNICAL UNIVERSITY DELFT

Fall 2010

Dr. Ir. J. Vollers

Pre Face

This document contains the combined work of six months of study. In the first semester of the master building technology a design is made for an innovative facade. Everything form the first ideas and concept forming to actual production of a prototype is studied. The first concepts have grown and have been optimized, many steps where taken before the final shop drawings where made. The prototype was made using these shop drawings and much knowledge is gained of how the design works and which improvements still can be made. During the process different techniques have been used to improve the design these all contributed to a better understanding of the possibilities for the different materials and production techniques. Like all designs this one has matured along the way and that process will continue, new techniques and materials might even make it possible to improve further than we now imagined.

Delft, Januari 2011

Acknowledgements

Our thanks goes out to the people and companies that have supported our research in many ways. Without the help of our tutors we would have missed some key information on design and calculating issues, although it is not always visible we do appreciate the fact that lots of their time and energy is specially reserved for us. Special thanks goes out to “Hurks gevel Techniek” and “Sorba Projects BV” for their financial support. Last but certainly not the least we would like to thank “Kees” and Louis from the TU Lab for their tips, tricks, support and knowledge during the building fase of the prototype.

Thanks.

Fig. 1

Hurks geveltechniek bv

De Run 4225

5503 LM Veldhoven

Postbus 284

5500 AG Veldhoven

T (040) 230 74 74 (040) 230 74 74

F (040) 253 82 85

E info@hurksgeveltechniek.nl

Fig. 2

Hoofdkantoor

Sorba Projects bv

Leeghwaterweg 2

7102 JJ Winterswijk

Postbus 18

7100 AA Winterswijk

T +31(0) 543 546 700 +31(0) 543 546 700 F +31(0) 543 546 701

projects@sorba.nl

www.sorba.nl

Table of Contents

Introduction

The course for which we designed this facade element is called bucky lab, its the first part of the master of building technology and architectural engineering. The goal is to design a part of a facade in an innovative way, this is to explore the unknown and to discover the world beyond. Materials and crafts have to be pushed to the limit. To be able to push our skills to a higher level, special sub-courses are offered where we are taught skills to use in the process of the design. One of the tools we mastered is the 3D design software Rhino that allows to draw and see how a design comes together as render pictures for presentations. In combinations with this there is a package called Grasshopper, this makes it possible to make a design respond to various input called parametric design. These tools make it possible to make the design visual, to know if it is going to be strong enough we have a program called Diana which can use basic drawings from the previous two programs to generate a geometry. This geometry can be loaded in several ways to find out how strong it will deflect and how forces are working in the model. Of course this gives us information on loading and tells us if a material is suited for its intended use. With this calculated data we can open a data base called CES where we can see and select the appropriate materials for the different components of the design. In this booklet we will take you along on a journey showing how the final result came to be, trial and error, inventing and perfecting. Different processes are shown giving an inside look in the birth of a new product.

Assignment

The starting point for this assignment was to design a innovative part of a building facade. The basic building to work with would be a standard office building thirty by thirty meters and eight floors high. Any part of the facade would be acceptable, the roof included. The difficulty of having a part that could open like a door or window was added to generate more interesting detailing although not the centre of gravity. Given the fact that many office buildings are made with an almost flush facade systems in our case we used this as a start. The main thing that was communicated was that the proposed design would have to be innovative. All students got this assignment and after 4 weeks we had to present our first design ideas, from this the best ideas would be chosen to be worked trough and these would be build.

Fig, 3 group picture,

Pre-design stage

Design concept

Personal design concept Johan

The Semester started out with a short period in which we had to design our own facade elements. I started out with some different ideas but ended this period with a design that combines a balcony and sun shading.

Description of the design.

The design proposes to use louvre sun shading on a building and making it possible to change this into a usable balcony. A set of rails and special connections combined with tension rods make up the basic idea. The main problems are the bending of the lightweight elements and the mechanics. If the bending is too severe than the balcony wont be usable. The mechanics behind the system need to do several things at the same time to make the design function a one piece, this proves to be quite a challenge not only to design but also to fabricate. These first sketches present the basic idea.

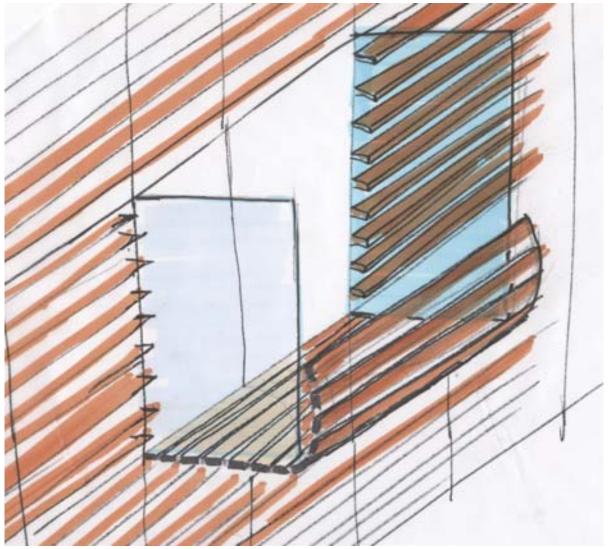


Fig. 11 Isometric sketch of the idea,

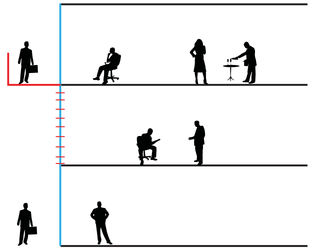


Fig. 12 Schematic view of the idea,

Combining often used louvre sun shading with the possibility to have a balcony, open doors and even usable for regular maintenance.

Inspiration

Fig. 9 Caterpillar reaching out,

Fig. 8 Roll up chair

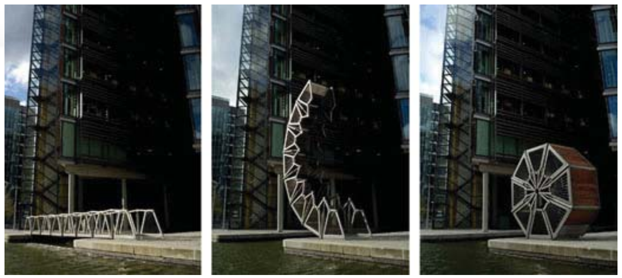


Fig. 10 Roll up bridge,

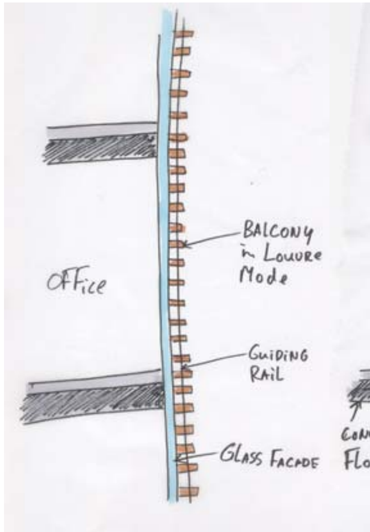


Fig. 13 Folded mode,

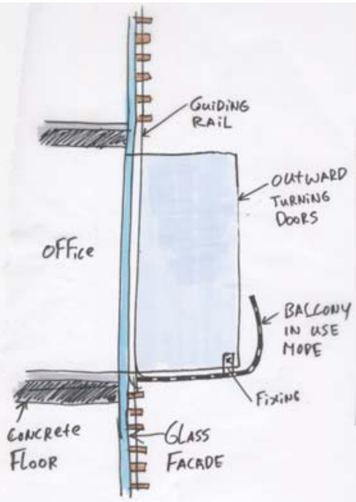


Fig. 14 Use mode,

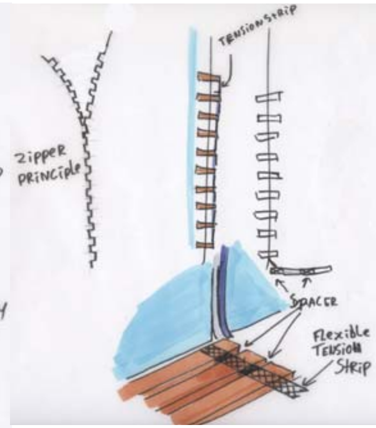


Fig. 15 Technical principals,

Fig. 16 Step by step animation,

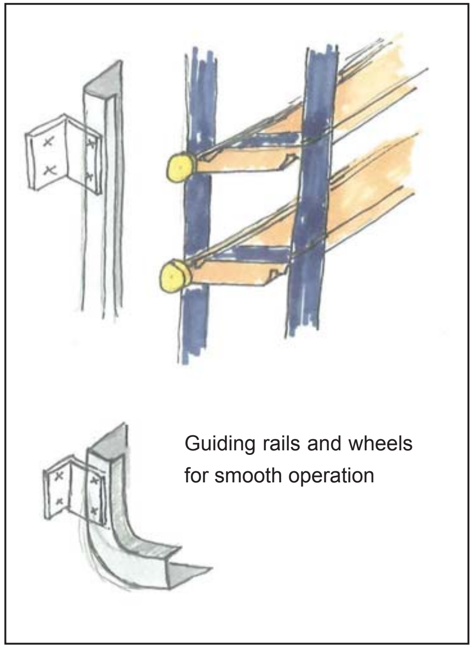


Fig. 17

Fig. 18 Closed, sun shading,

Fig. 19 Open, balcony,

Fig. 20 Top view,

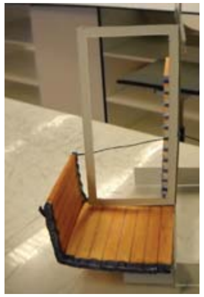


Fig. 21 Inside view,

Note, this is only half the model. in real 2 doors are needed to close the sides

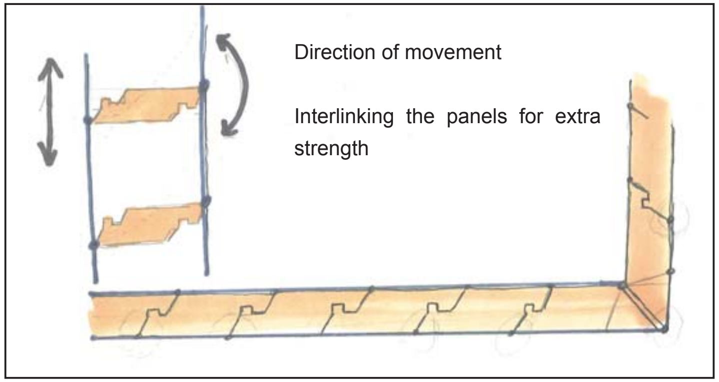


Fig. 22

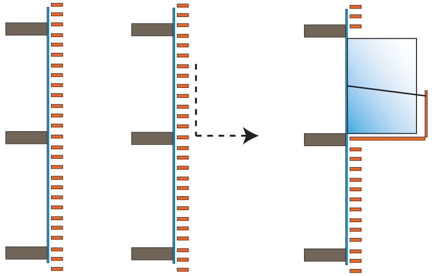


Fig. 23

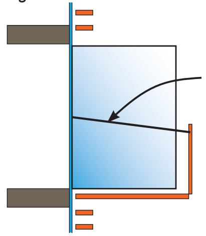


Fig. 24 Steel cable for expanding the balcony

Fig. 25 Gear drive to open and close the balcony

Personal design concepts Erik

All the designs I made are related to energy efficient buildings and concepts. At first I writhed same important words down on a brainstorm about energy efficiency. I've concentrated on the most important words of the brain storm and kept in my head the changes of the recent decades of facade design and came to 3 solutions.

My first interpretation

BRAINSTORM
- double facade
- fits to every function
- double curved
- form
- sun/wind/rain
- supporting/not supporting
- 100 % transparent
- moving
- colors
- materiel
- low budget

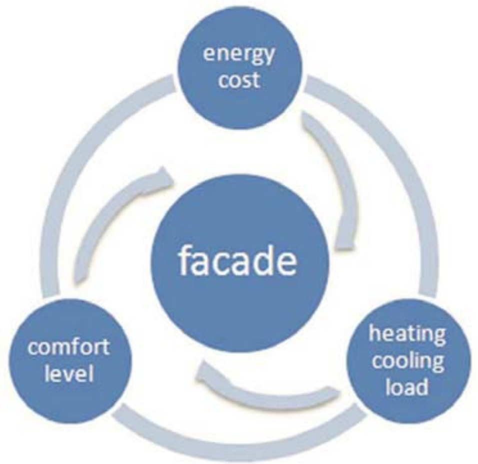


Fig. 27

HISTORY ----> 2010

- very closed to open facades
- more installations in façade
- more expensive facades
- facades needs more energy to produce

Fig. 26 historic facade,

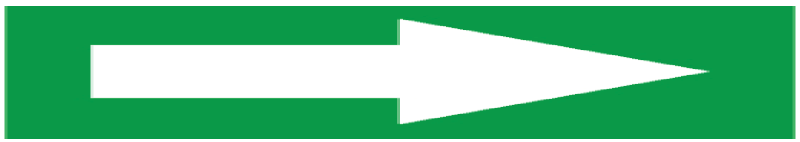


Fig. 28 modern facade,

useing free enery

HOW?
You move the transparent parts ore you cover them.

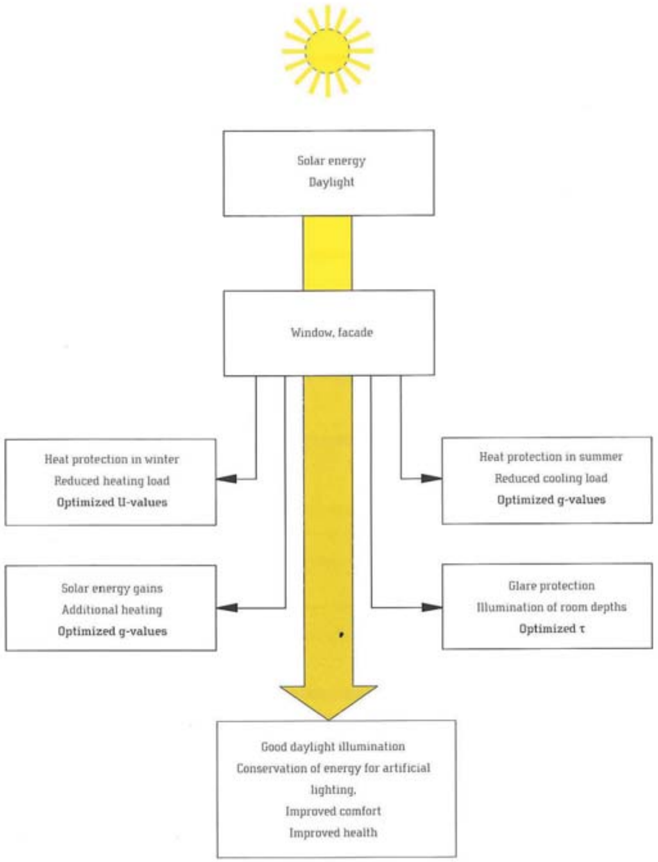


Fig. 29

1. Multifunctional facade

The first design is about the total package of integrating the installation, construction and the climate control system in the out her layer of the building to create a total open office or shopping space. This will optimize the use of useful square meters of the building and the internal work environment.

the benefits are:
-extra free space
-comfortable quality of life
-zero energy use
-extanding building life

-transparant
-installation
-construction

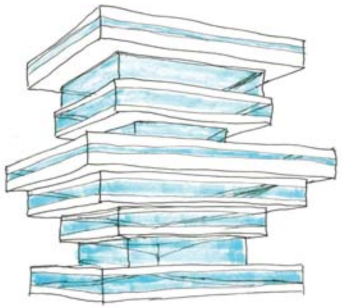


Fig. 30 front view,

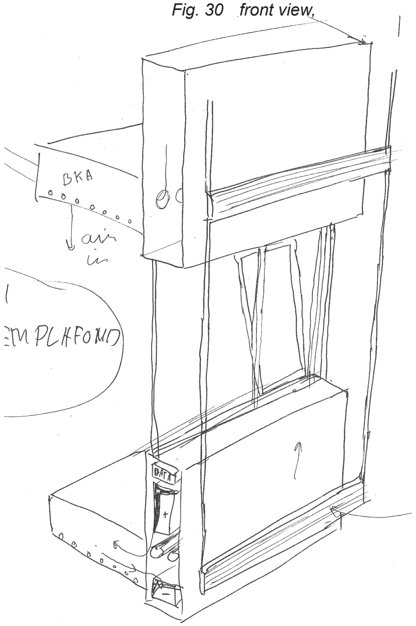


Fig. 31 perspective,

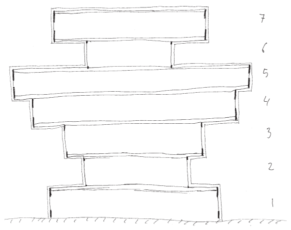


Fig. 32 section,

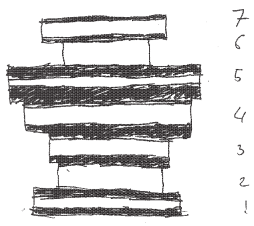


Fig. 33 front view,

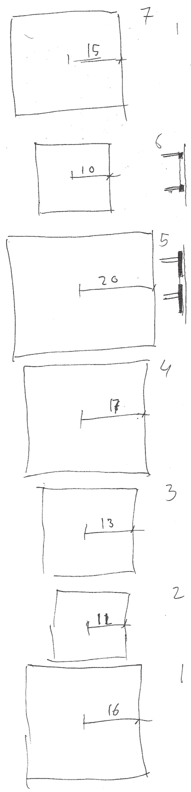


Fig. 34 floor plans,

2. interactive skin

The interactive skin is the second design that has the promote the internal climate and work space of the building. By opening the furs the building can lose his heat at night in summer time and by closing it at day time it can keep the internal space cool. By aiming the furs straight on the sun at winter time the building can be over 80% transparent and receive the maximum solar heat. It would be a very interesting design for a 1:1 scale prototype because of the technical parts to move the furs freely in a 3 dimensional way.

Fig. 35 fur,

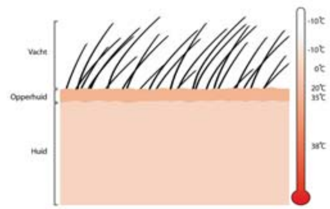


Fig. 36 temperature scheme,

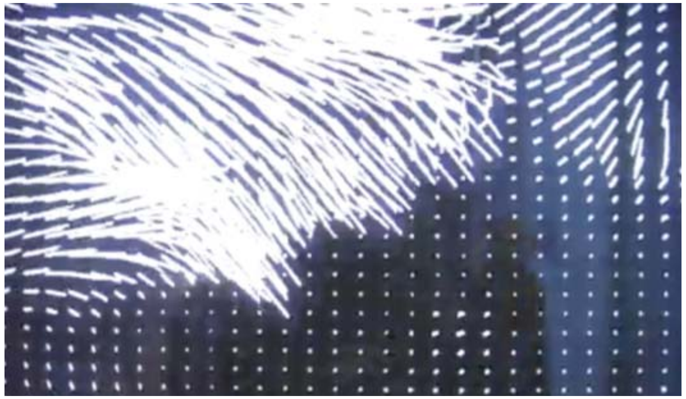


Fig. 37 inter active wall,

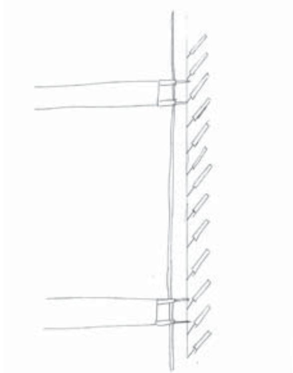


Fig. 38 fur to sun,

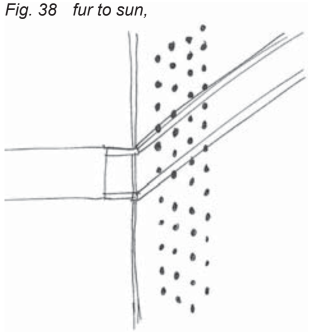


Fig. 39 fur open,

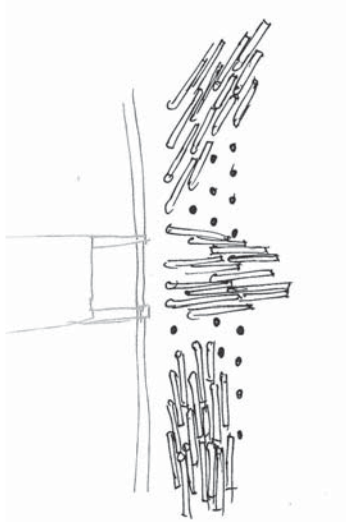


Fig. 40 fur different positions,

3. Structural skin

The structural skin is the third concept and also the one which I prefer as the best concept. The skin combines the construction, and the climate controlling part of the building like a BLOB. By moving the window inside the concrete honeycomb the heat of the indoor space can be controlled. When the glass part is moved to the outside of the building it will generate heat behind the glass, this heat will be circulated through the building and warm up the internal space. By moving the glass to the inside of the building the concrete wall will provide shading. The height of honeycombs depends of the orientation of the facade. On the north side they can by like over one meter high and on the south side maybe a maximum 20 centimeters.

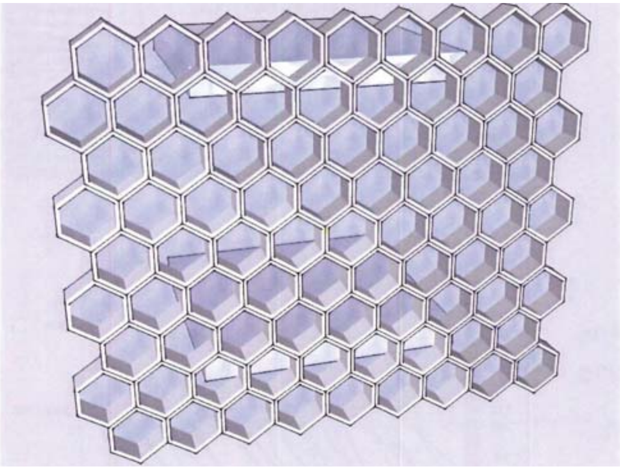


Fig. 41 front view,

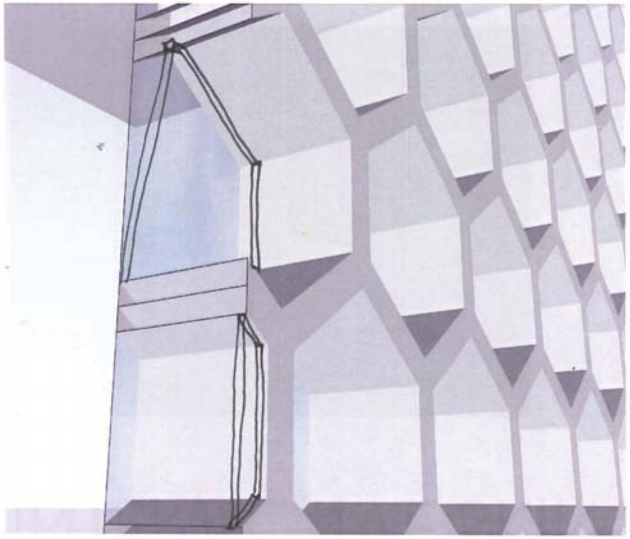


Fig. 42 section glass,

Moving parts of the glas

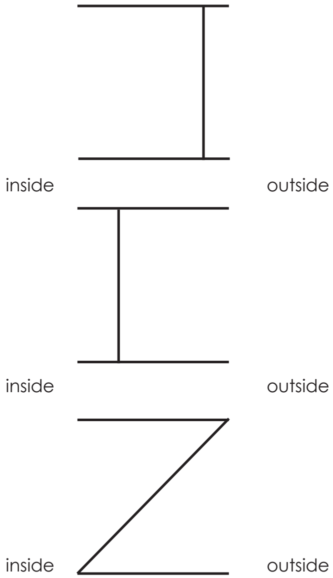


Fig. 43 abstracted schemes,

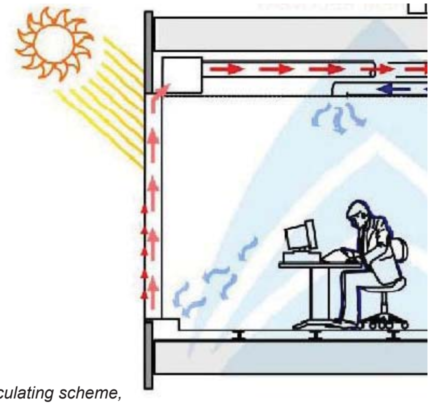


Fig. 44 solar circulating scheme,

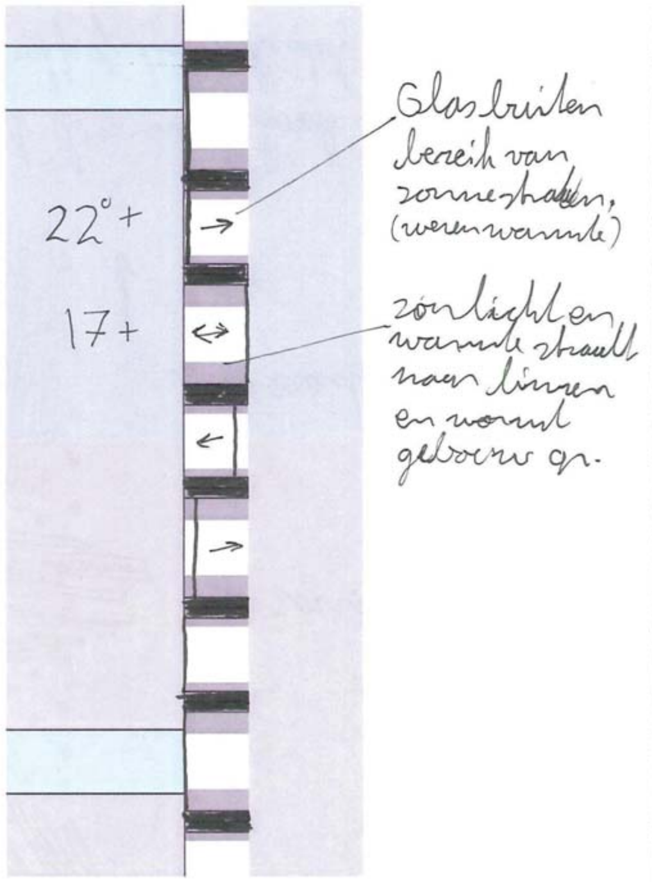


Fig. 45 temperature section,

Calculations

- form
- angel
- the depth of the glass
- winter/summer
- climate

benefits
- less material use
- All sides can be adapted to orientation

Selection procedure

After the first period a selection was made by the tutors. The selected works would be taken to the next level and developed into a working prototype. From the presented sketch ideas in the previous chapter the combination of the sun shading and balcony was approved to be one of the designs that would become a prototype. In the following this design will be described. The motivation to continue with this design was mainly the way it poses to be technically challenging.

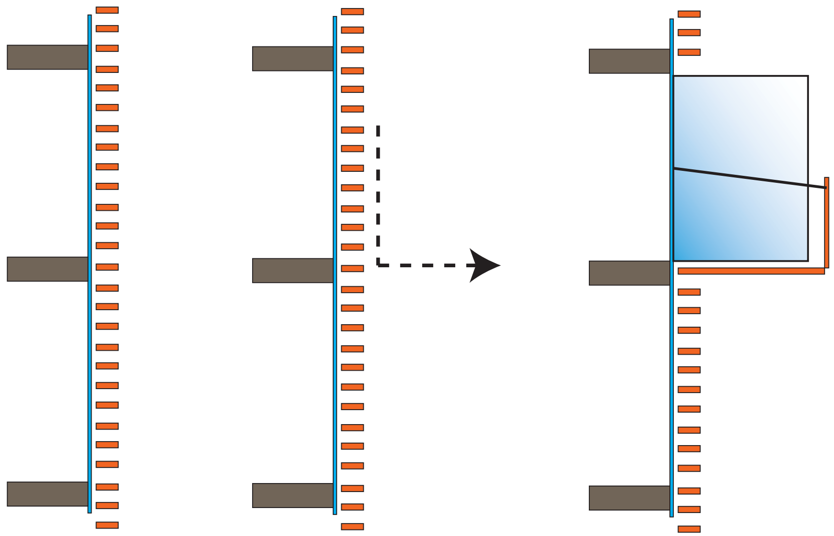


Fig. 46

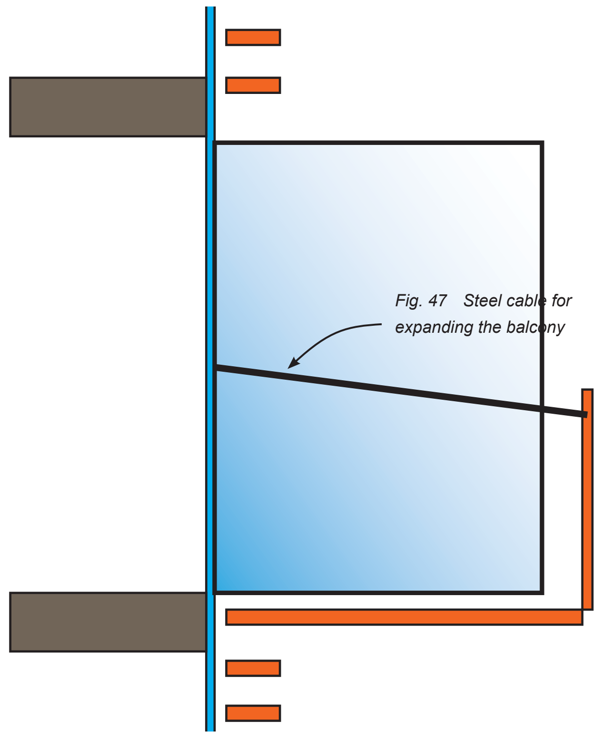


Fig. 47 Steel cable for expanding the balcony

Concept development

Defining concept rules

After the first weeks and the Selection the Dynamic balcony was chosen as one of the many designs that would be further developed. The ultimate goal is to build the design in a prototype version, not completely building a building and facade but just the part that is subject of our design. Than there is the thing that makes this design different from all others and defines if it succeeds or fails “The Concept”. A concept comes with rules that define it. In This case the clean use of the outside sun shading that is transformed in to the balcony. The reason to use outside sunshading is that this is much more efficient, as the suns heat is released on the outside of the building. The reason to use the sunshading is a double way is that integrating helps to keep the facade thin and saves on materials and space.

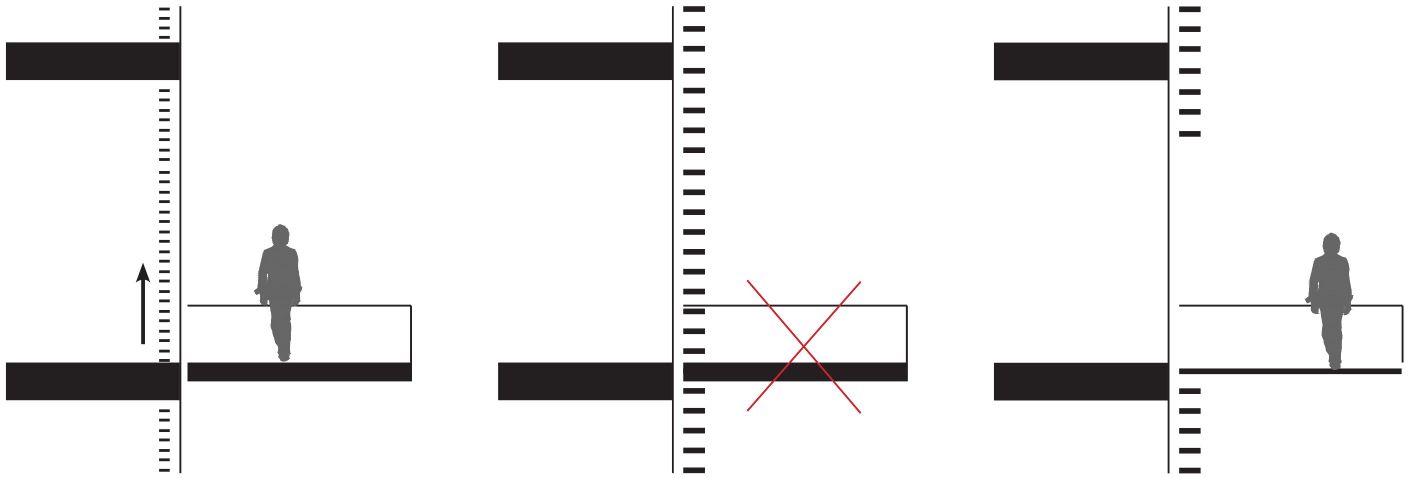


Fig. 48

high quality internal environment ✗
balcony ✓
outside sun shading ✗

high quality internal environment ✓
balcony ✗
outside sun shading ✓

high quality internal environment ✓
balcony ✓
outside sun shading ✓

Defining technical problems

The two basic forms that need to merge come with there own technical problems. Sun shading needs to be adjustable to full fill its purpose. At the same time a balcony should be as rigid as possible to function properly. The technical problems which are normally quite easy to solve now become to be a real challenge as almost all parts need to be able to move from one setting to another. The panels that form the main element are to be as light as possible and although thin in the sun shading setting also need to be able to take the loading in the balcony setting. Where the connecting rods are all it takes to keep the sun shading up and movable, in the balcony setting they are only use full to make the panels link in the exact space. Where the panels become the floor of the balcony these need to be locked to each other. To do this a special locking bar is inserted in the edge of the panels, this prevents the panels from moving in a undesired direction. The panels are locked and move out in a horizontal fashion becoming the balcony. As this happens the gravity wants to pull it down, this is prevented by adding a double set of tension rods that takes away the bending.

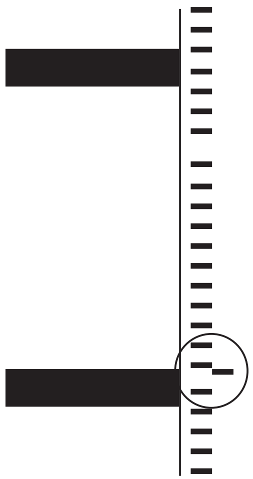
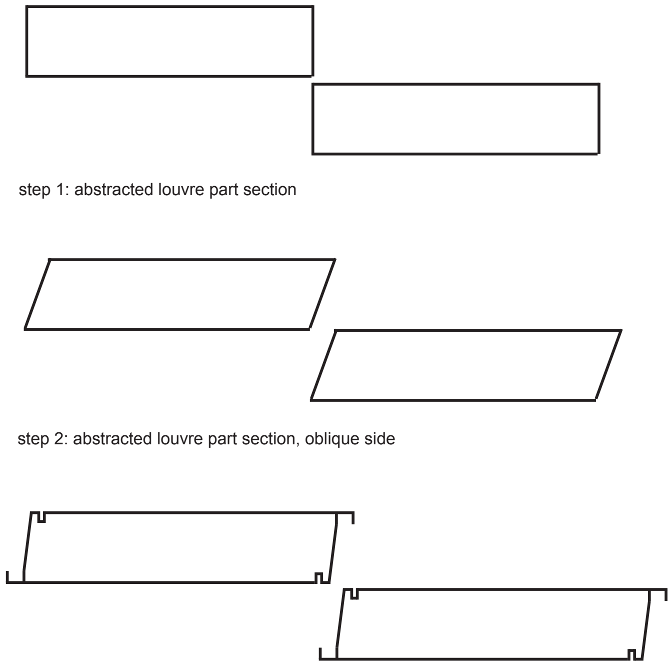


Fig. 49 abstracted facade scheme,



step 1: abstracted louvre part section

step 2: abstracted louvre part section, oblique side

step 3: abstracted louvre part section, steel profile to fix the parts,

Fig. 50

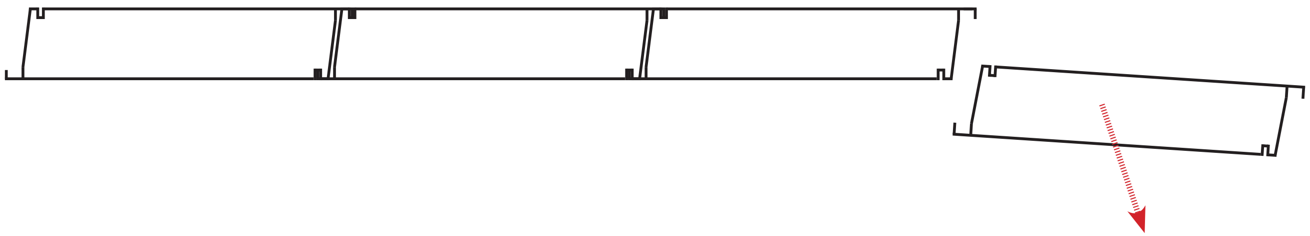


Fig. 51 problem in fixing louvre parts in balcony setting,

Listing of priorities

As there are many problems to solve we made a list with the most important ones. To solve all problems at once would be a very complex process, to divide the problems in smaller bits and giving them a priority we got a way to solve the bigger challenge.

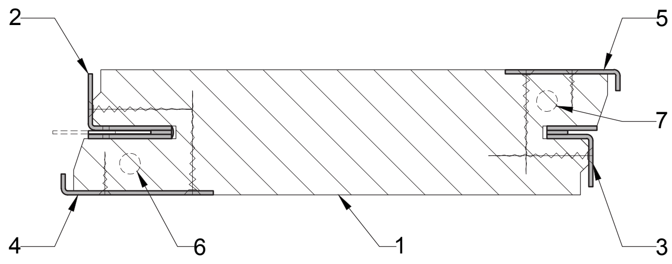
BT-04-01

1. wood-base
2. male switch mechanism
3. female switch mechanism
4. in equable angle
5. in equable angle
6. axle, 250mm
7. axle, 250mm

BT-04-02

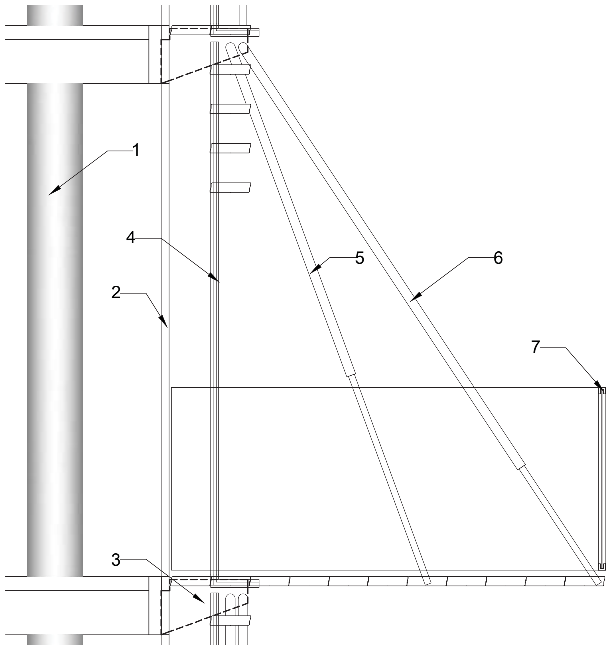
1. basic construction
2. thermal layer
3. auxiliary construction
4. rails
5. compression / tension rod a.
6. compression / tension rod b.
7. balustrade

BT-04-01:



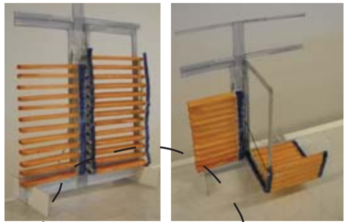
section panel

BT-04-02:

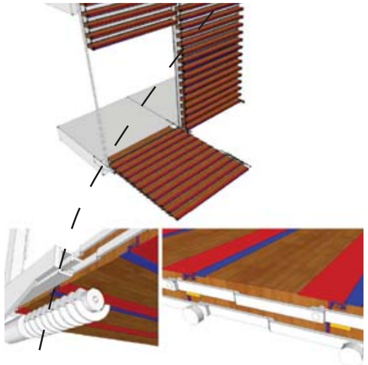


section facade

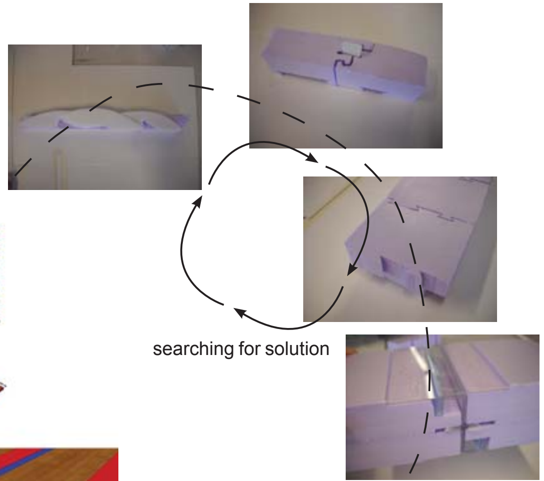
Process chronology



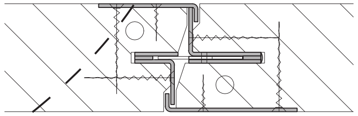
pre-design stage



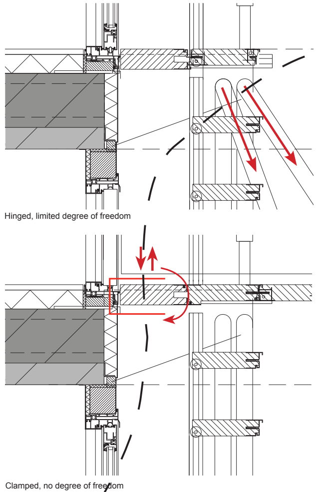
defining model



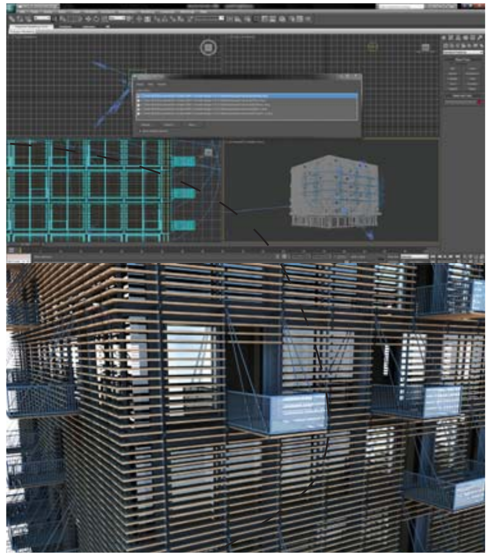
searching for solution



final louvre connexion

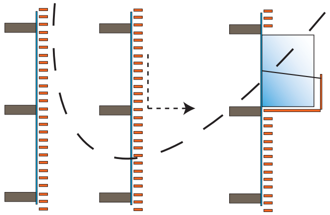


calculate the model

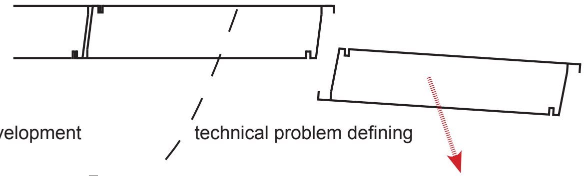


final 3D render

september | october | november | december | january | february



concept development

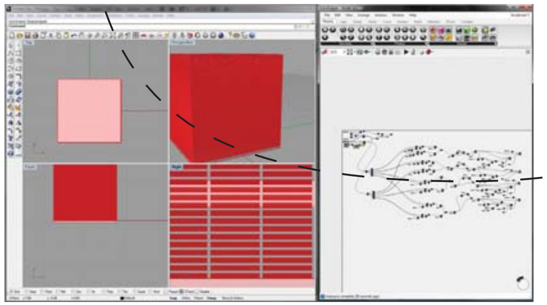


technical problem defining

hurks geveltechniek

sorba shaping architecture

making the prototyping possible



searching for the best louvre size

making the first model to define problems

building the final prototype

Development

Technical studies

During the development of the prototype many design problems are encountered. To solve these issues technical studies are done, often in the form of testing small scale models of the intended shape. These tests give a precious insight in how things come together and if brainwaves have any chance in a real world. In the photo series on the right hand side photos are shown of the studies that where done to find the interlinking system that was needed to connect the individual panels into one solid walking platform that could service as a balcony.

Use of computer

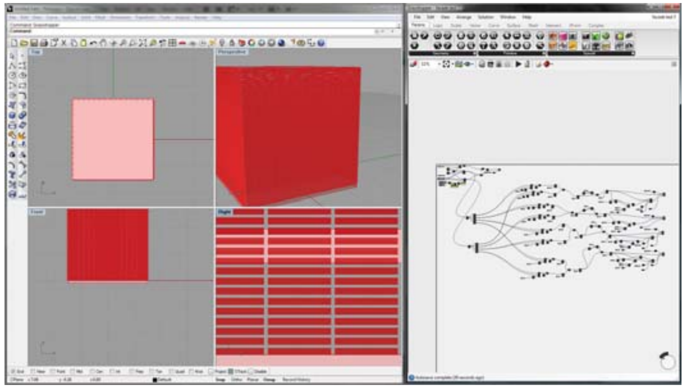
The computer is used throughout the whole design process sometimes more intense sometimes less. At first we started with sketches and model like in the right. We first drawn de models in AutoCAD for the exact measurements. To define our design ideas and to make them more clear and usable for presentation we worked them through in Illustrator and Photoshop. This was the first fase where a computer came around. After the selection of the concepts the idea was worked through to see how this would need to be improved.

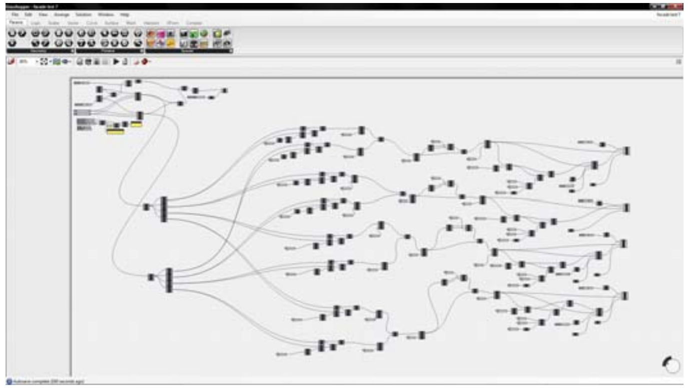
We also used sketchup to make sure no technical moving part of the shading parts and the secondary construction colide with each other on the model. The reason we did this, is that we save a lot of time by drawing this in a 3D model in stead of building the phisical thing. Its still sort of a sketsch but accurate enough for the first model and it works very easy and fast.

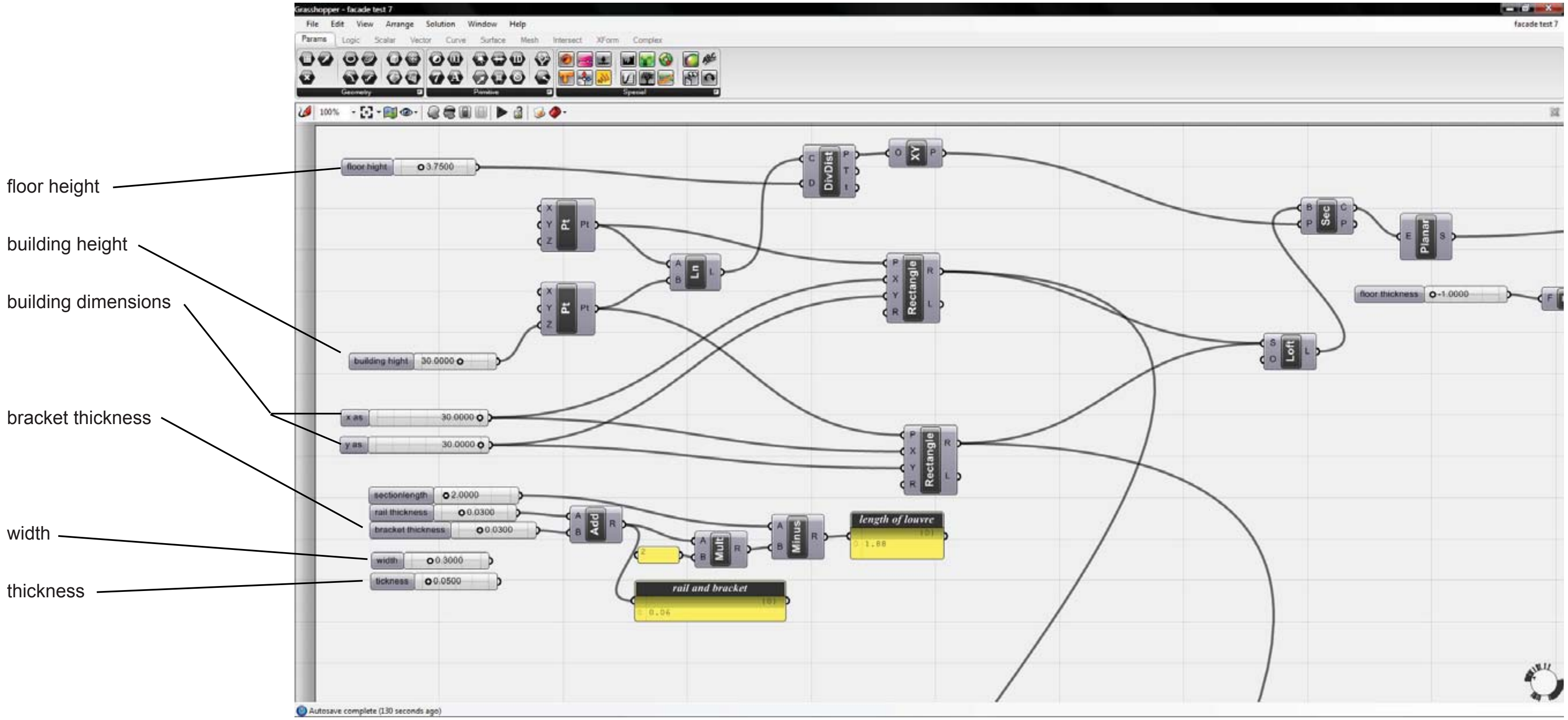
Parametric design

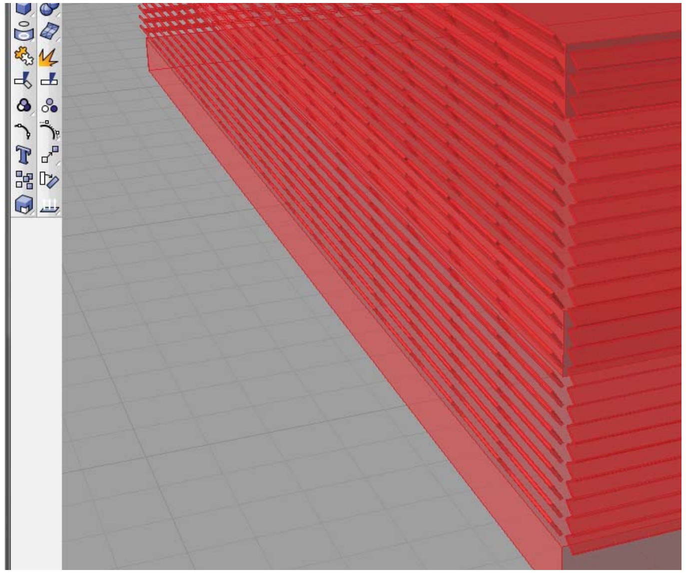
To find the best size for the different parts we used Grasshopper, a special parametric program that makes it easy to change a small part of the design and see how this affects the rest of the design.

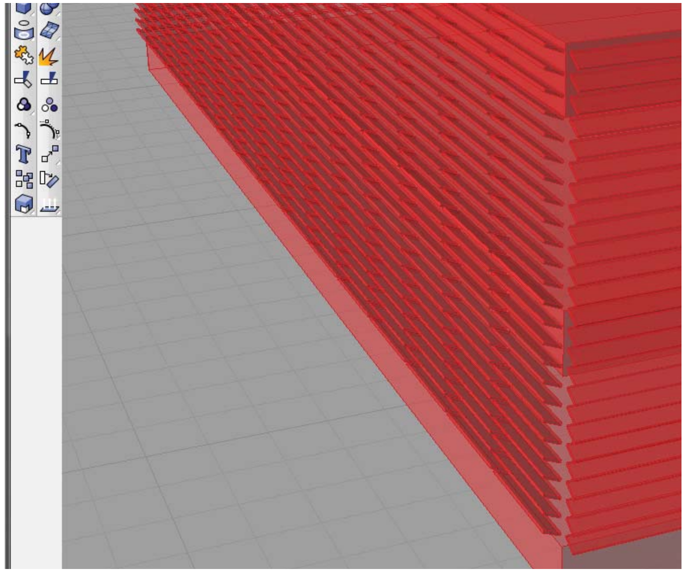
To find out the most economic and shading form for the louvre parts we made the model in Grasshopper. We tested the length, thickness, depth and the distance between the different louvre parts. By using this parametric program we could do this by just turning one button and the whole model reformed it self. The programm alowed us to test many different shapes and settings and provided lots of information to use further along in the design. I find this an very interesting type of modelling and saved us a lot time.

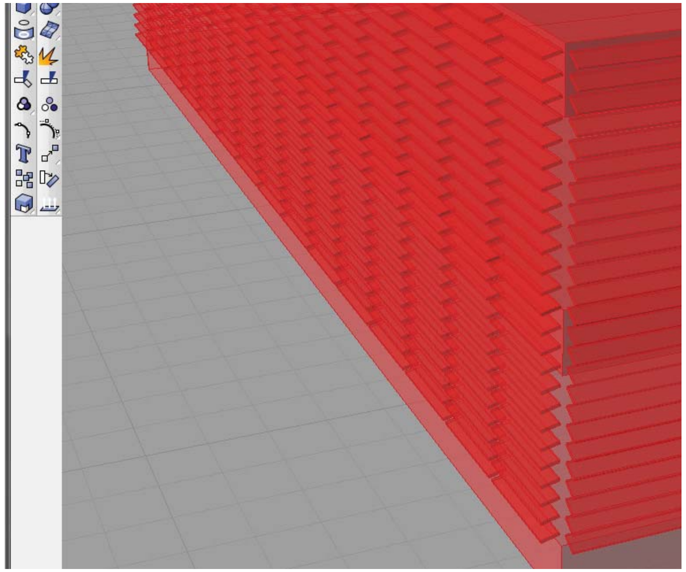


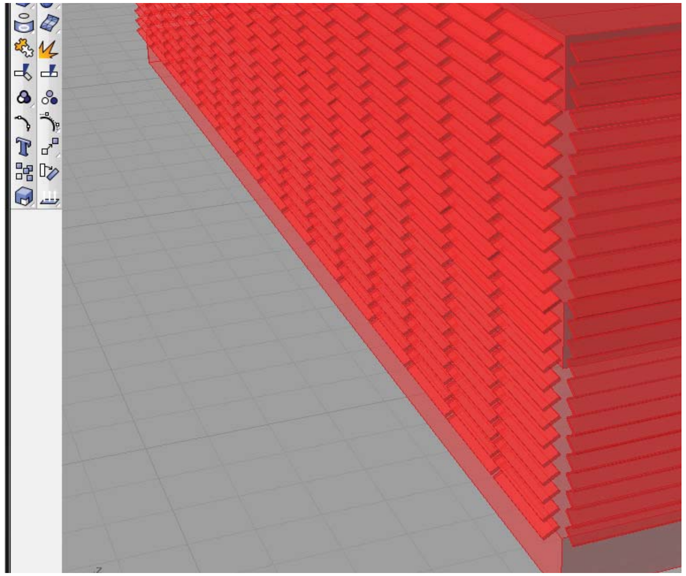


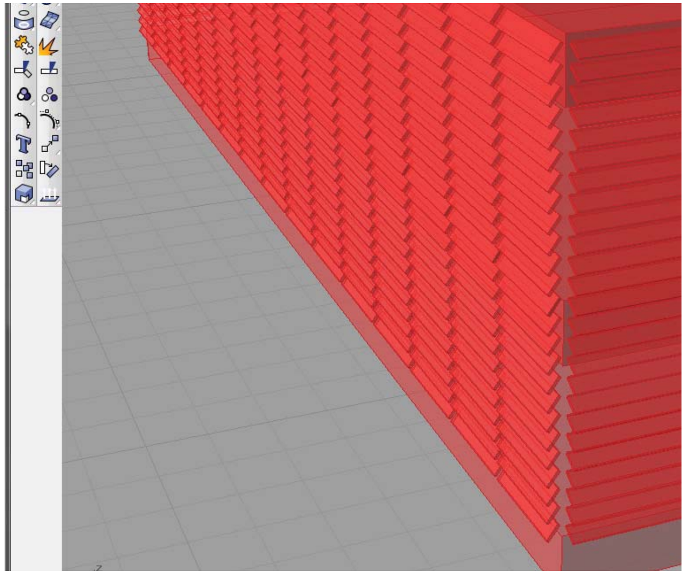


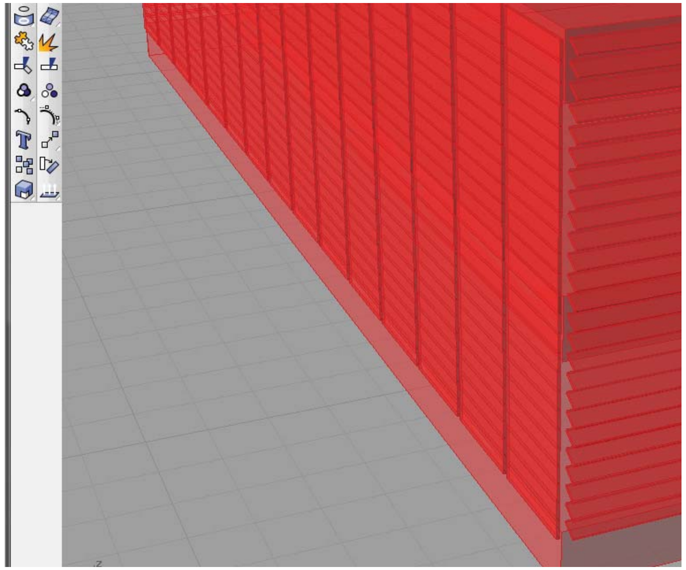

Angel louvre part: 30 degrees


Angel louvre part: 70 degrees


Angel louvre part: 90 degrees

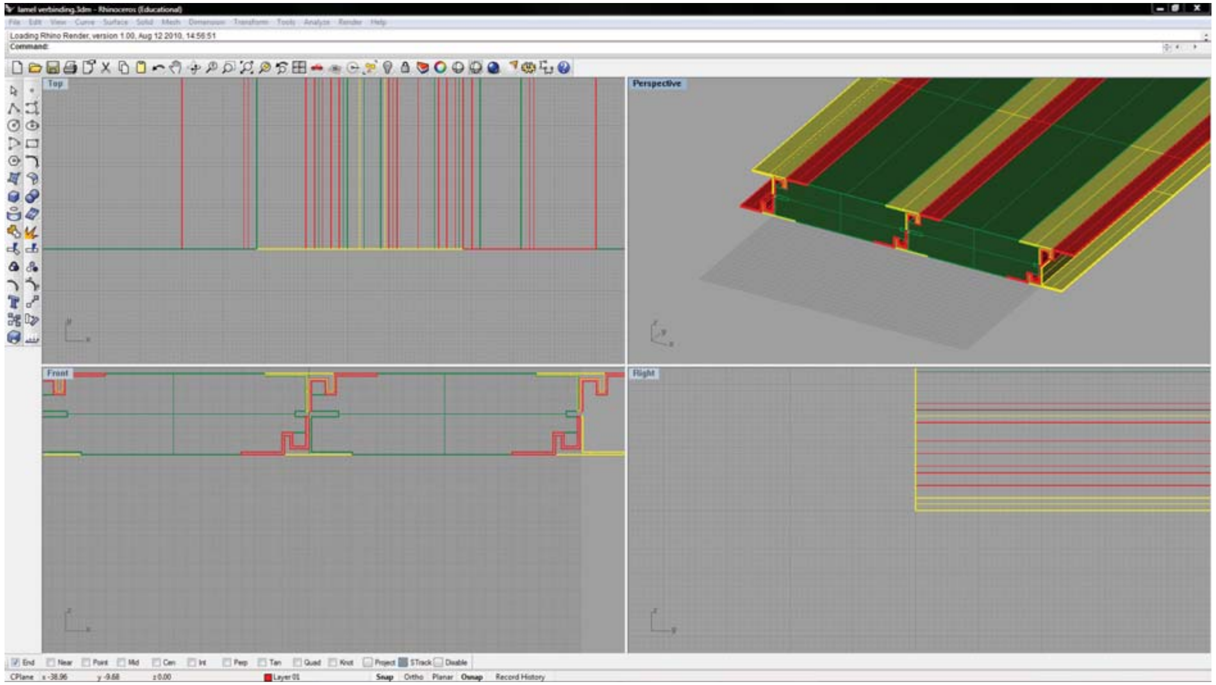

Angel louvre part: 120 degrees

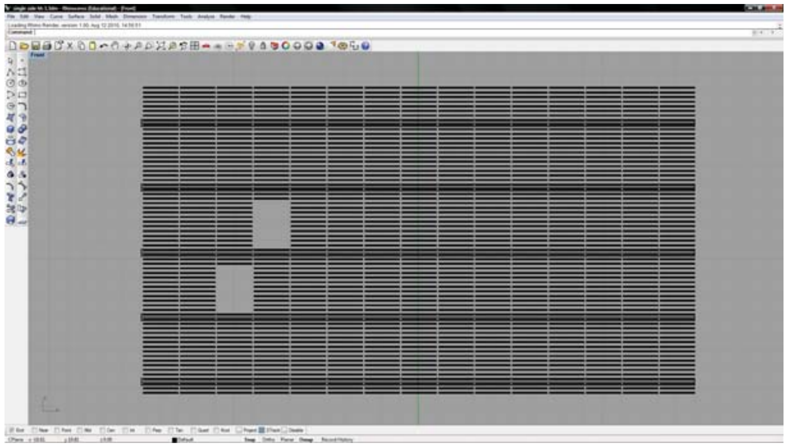

Angel louvre part: 150 degrees

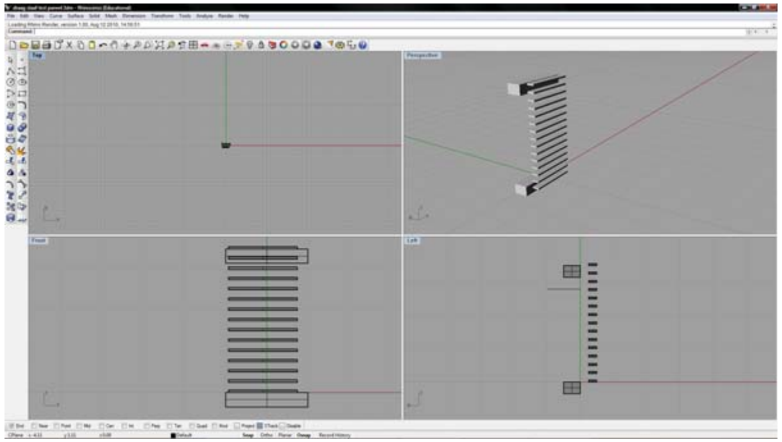

Angel louvre part: 180 degrees

Technical drawings

To make the prototype drawings are needed, dimensions need to be found and all parts need to come together. We started out to make a base drawing in Auto-cad to try and find the trouble spots this was done simultaneous with the use of Google sketch-up to make a 3D model. At the same time physical models where made to test the different parts and functioning of the mechanism. The physical models gave us the connection, this connection is presented on this page drawn in Rhinoceros. The model was easily exported to iDiana to calucalate the forces in the louvre parts.

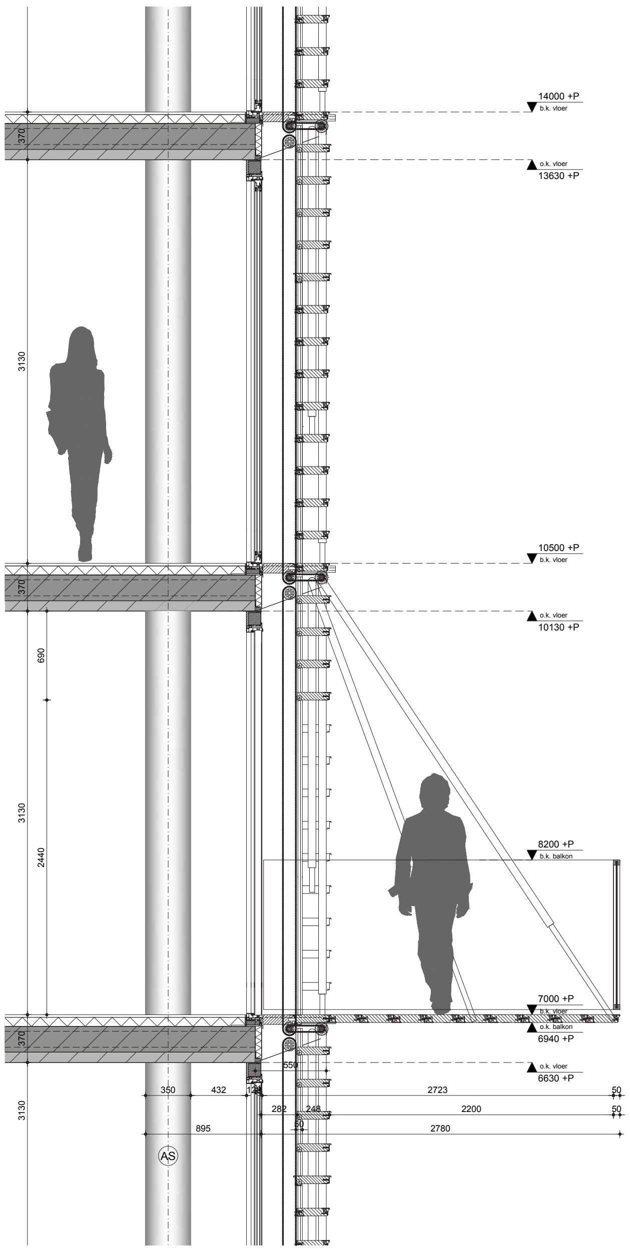




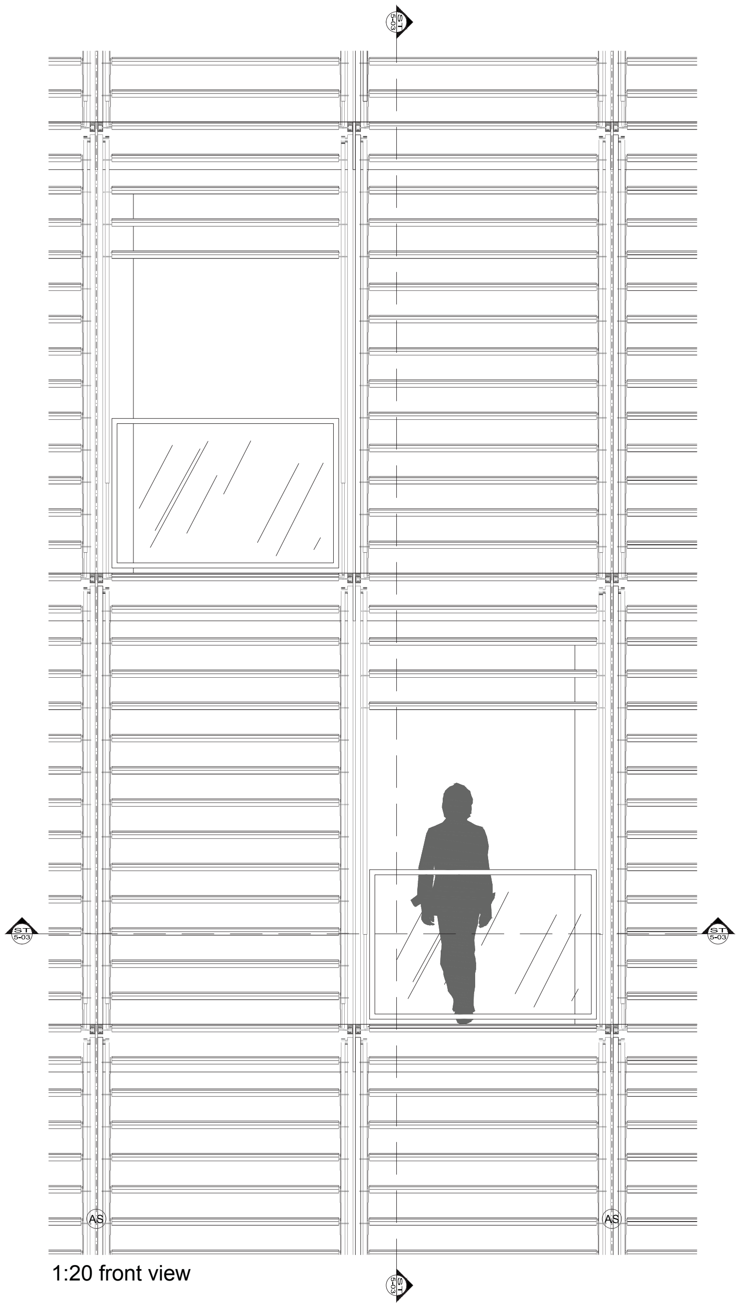


Primarily used software

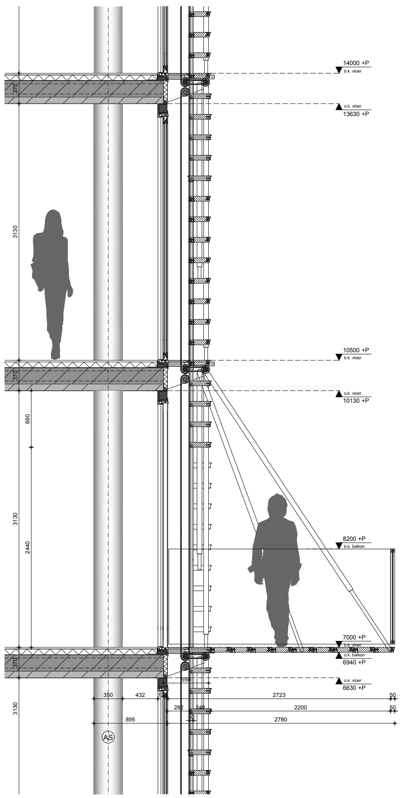
Several drawings where made and a overview of these was compiled on a large sheet to use for meetings with the laboratory staff. We also made a A3 booklet with technical drawing 1:1 and 1:5 to help us building the prototype. We have done this generally with 2D polygons. We didn't used the NURBS because the model we needed did not include difficult 3D geometry.



1:20 cut section

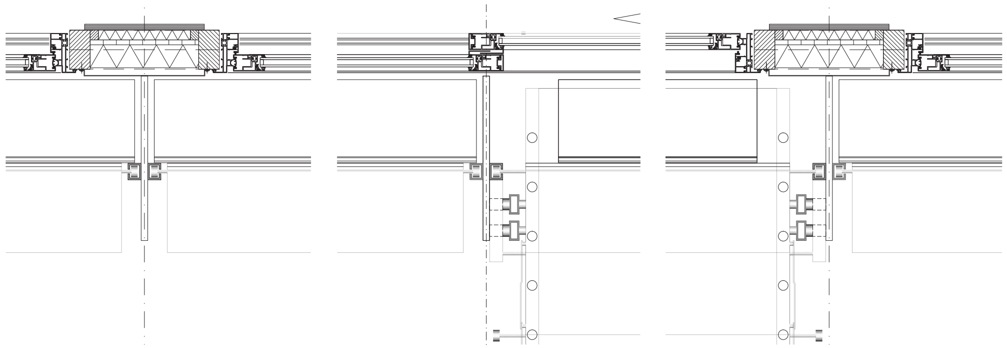


1:20 front view

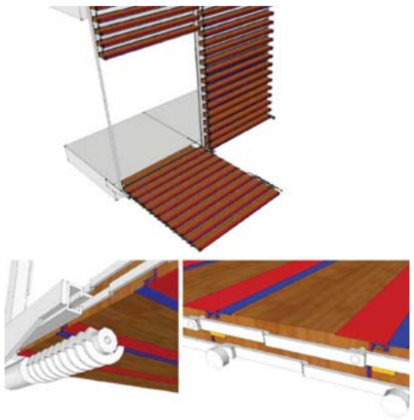


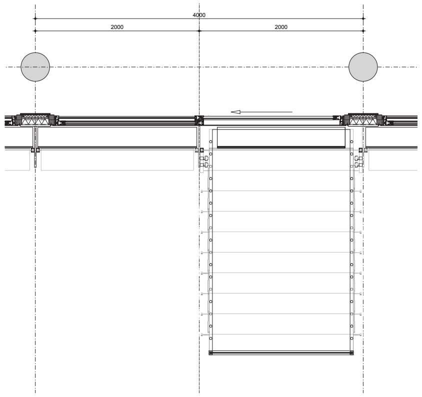
1:20 cut section

1:20 front view

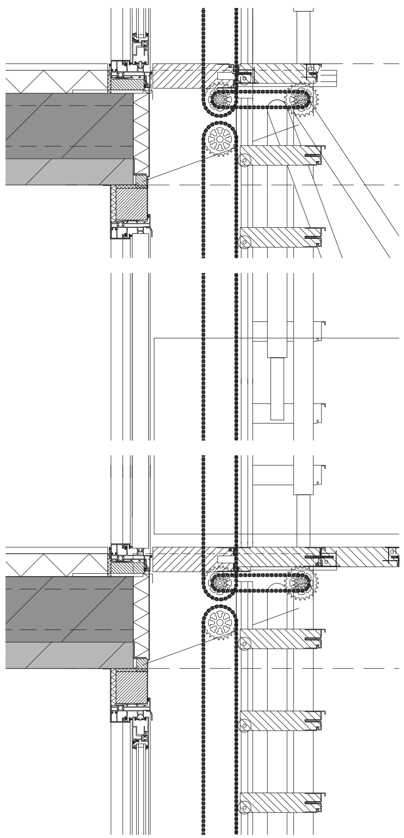


1:5 detail horizontal

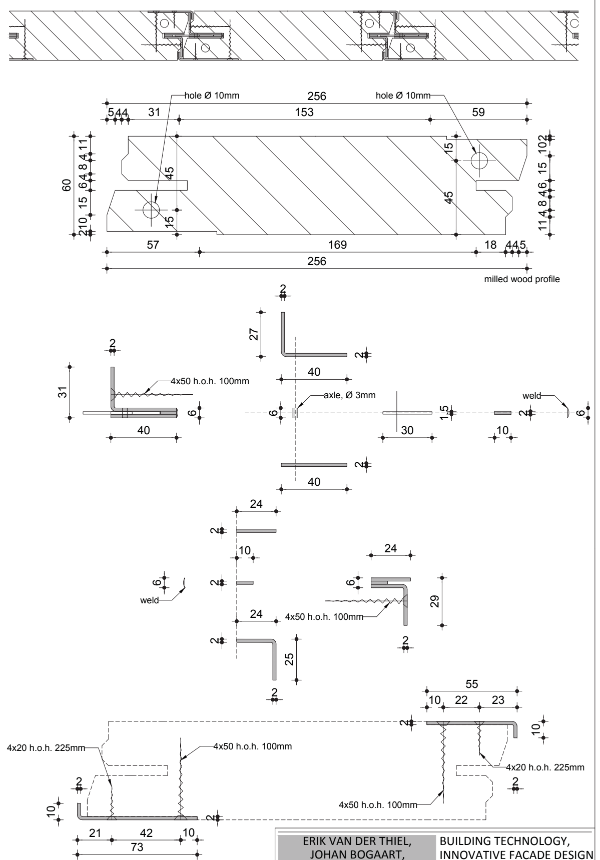




1:20 floor plan



1:5 detail vertical



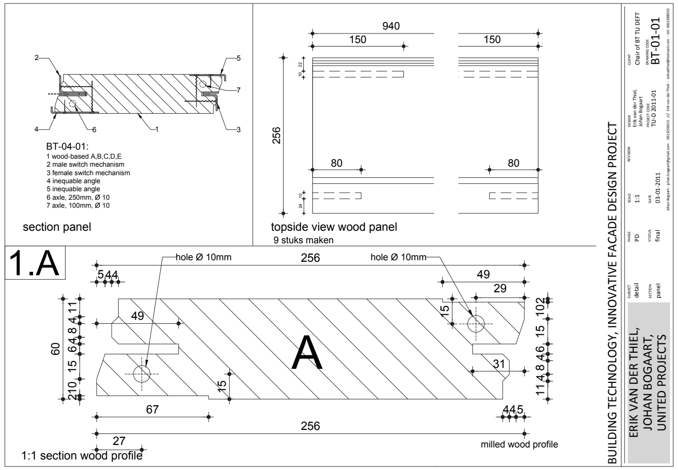
1:1 detail

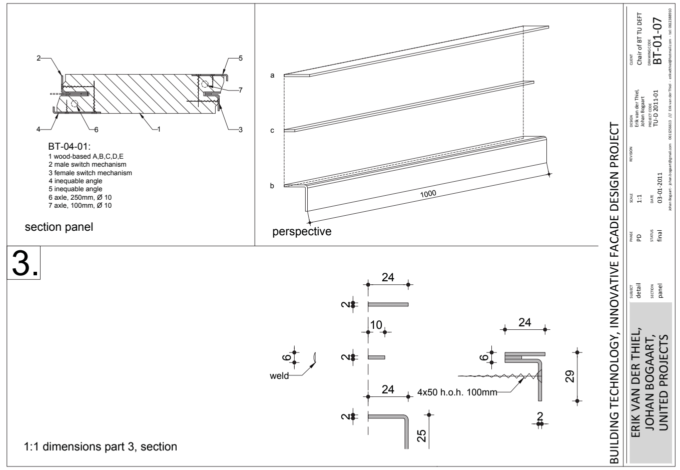
ERIK VAN DER THIEL, JOHAN BOGAART, UNITED PROJECTS

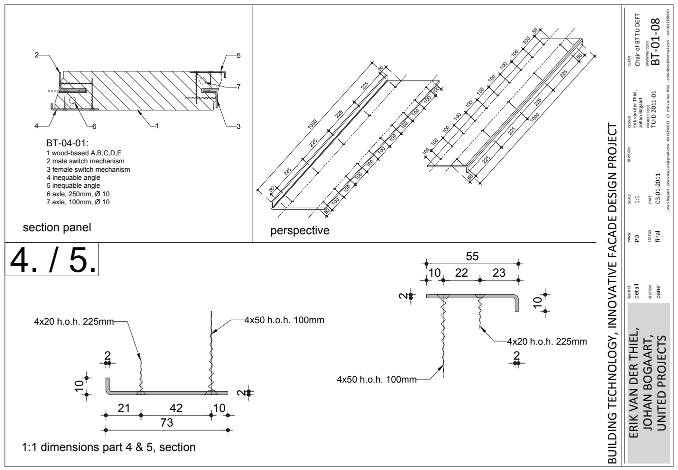
BUILDING TECHNOLOGY, INNOVATIVE FACADE DESIGN PROJECT

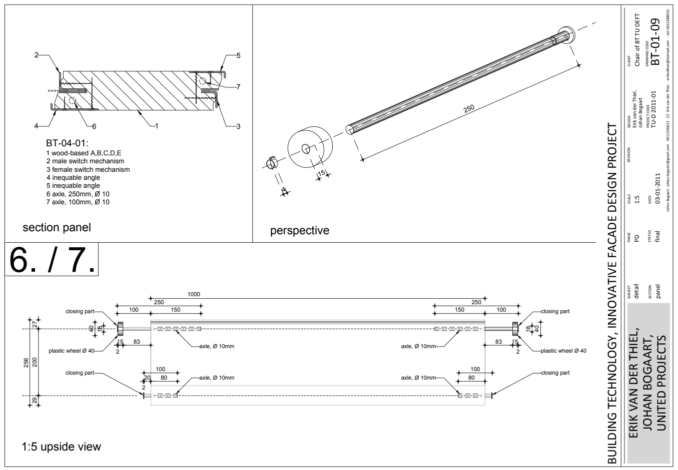
project overview	1:20/1:5/1:1	Erik van der Thiel, Johan Bogaart	Chair of BT TU DELFT
general	28-01-2011		
PD		TU-D 2011-01	BT-05-01
Final			

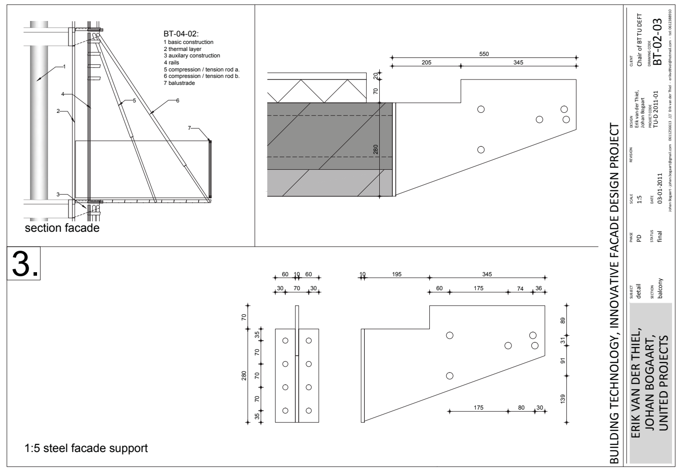
A few examples of the 1:1 and 1:5 drawing we made in AutoCAD to show some of the result. (in general each drawing is printed on a A3 paper)







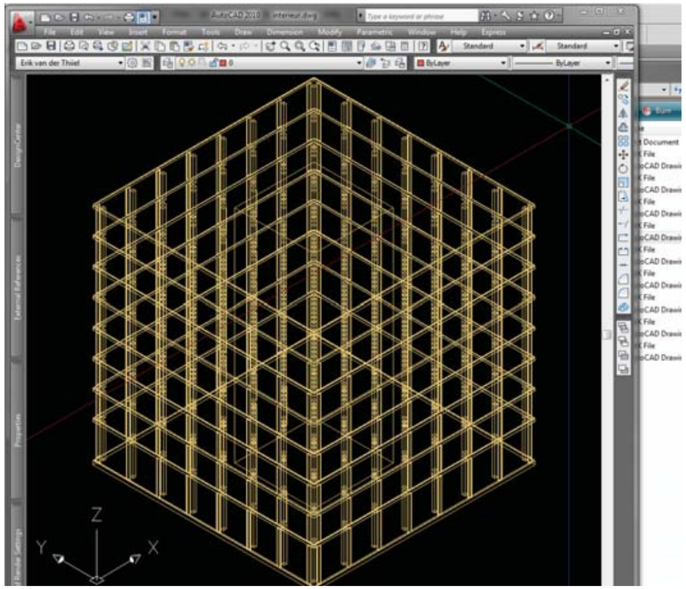




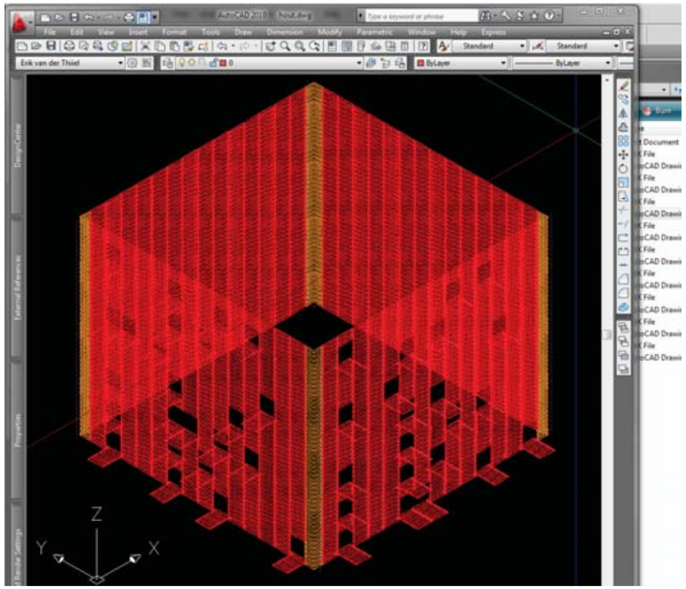
Software interactions

To make the shop drawing the use of AutoCAD was enough. We made some 3D models in sketchup to make sure there where no crossover points in the model. In this case we didn't used the interaction of any software.

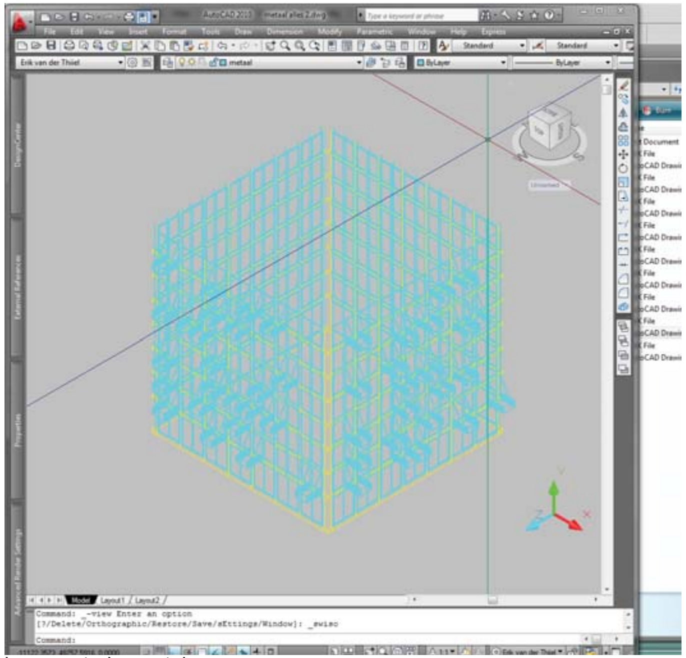
Instead of the 2D drawing we used several combinations of programs for the 3D model. First we made a basic model in SketchUp, we did this because it works fast en accurate enough. We exported this to AutoCAD maintaining the layers. This because you need all the different materials in a different layer to later on attach the right material in 3D Studio Max.



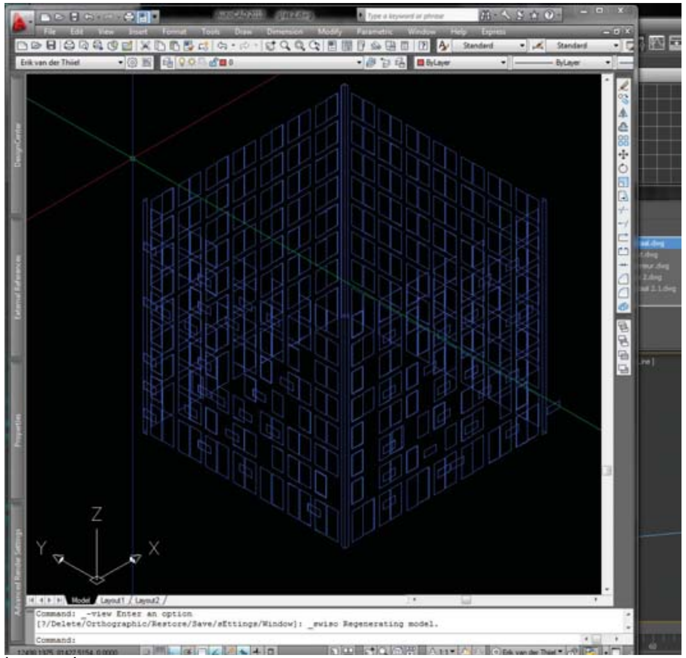
layer: interior environment



layer: wood

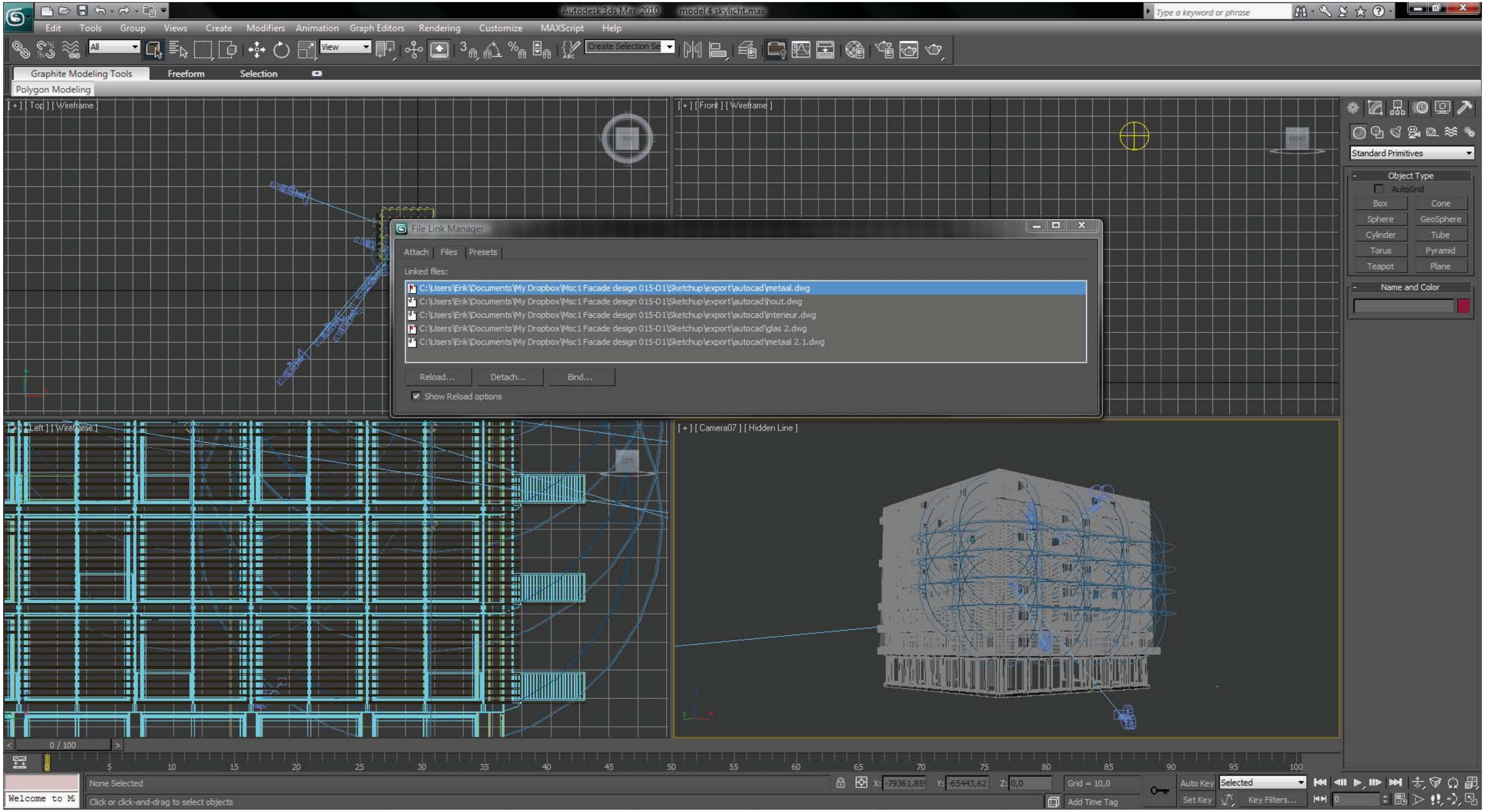


layer: exterior metal



layer: glass

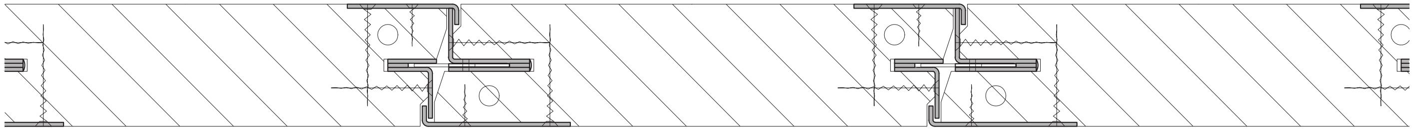
To make sure we can use the AutoCAD drawing we link them in 3D Studio Max with the File Link Manager. The benefit of this functions is that you can load several large drawing into one file by just linking the drawing and than hide it and load the next one. You can also update the basic AutoCAD drawing in 3D Studio Max when then model automatically update the new line in the specific layer with the right material. So you can work in light drawing and only unhide every thing when you make your final render.



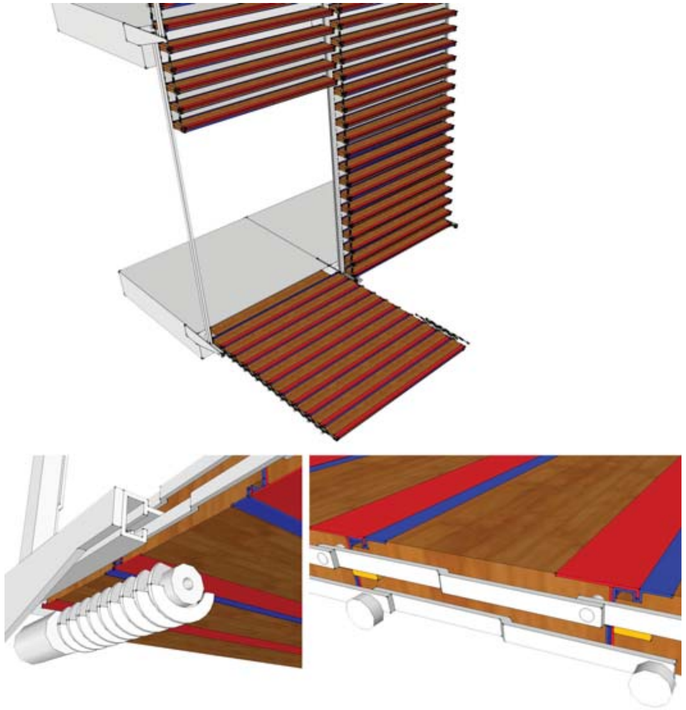
Final renders

Build vs calculation

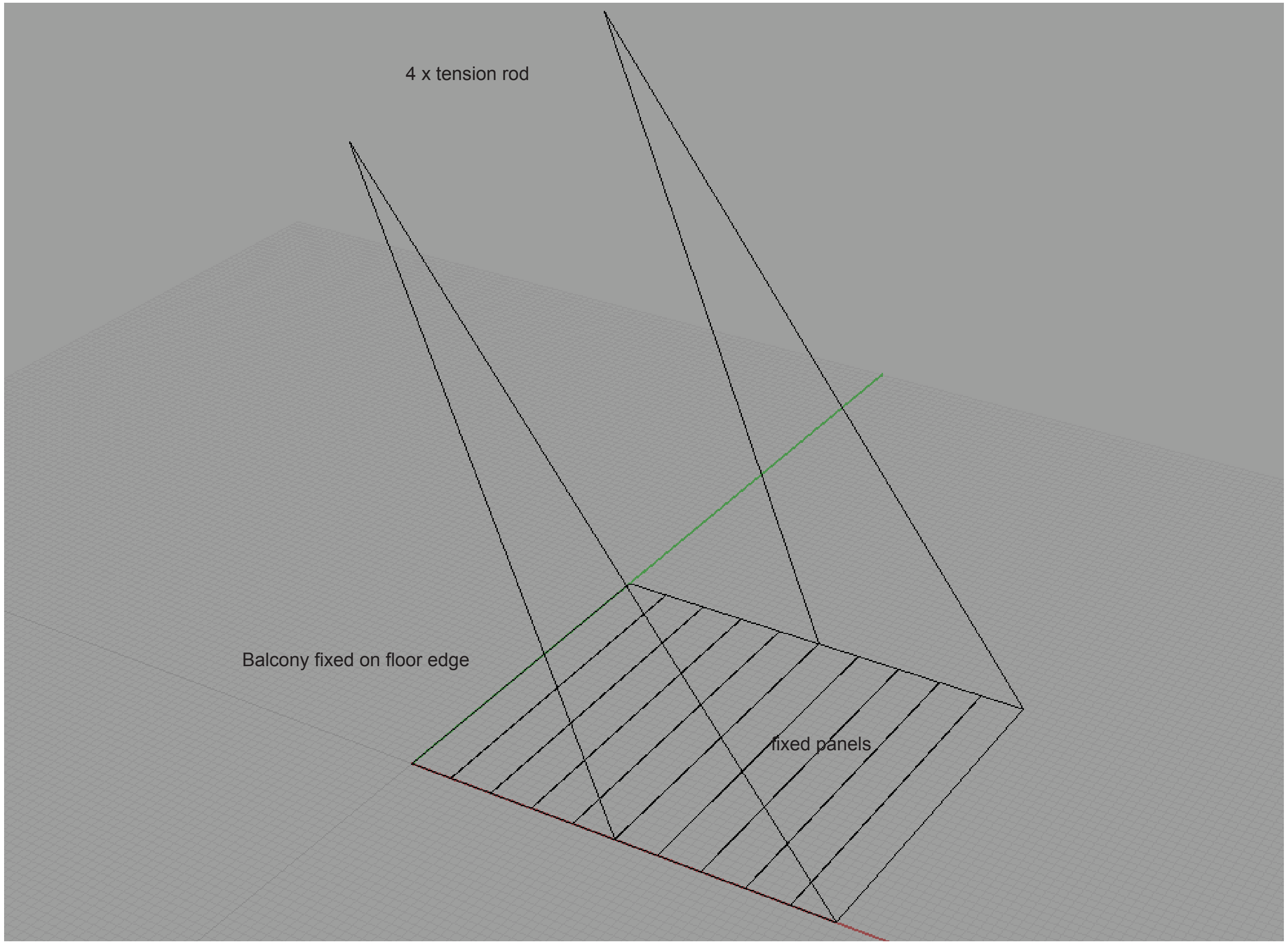
The model that is build in real life differs from the one that is been calculated. This is due to the fact that lots of irrelevant information would make the calculation slow and unreadable. To solve this issue an abstract has been made which only shows the bare necessities and leaves everything else out. Shown are the parts that play a key role in the design and are subject to the expected forces. This basic model is made in Rhino and exported into the iDiana software. It worked very smooth, and it was easy to deform the model and play with different setups.



fixed panels



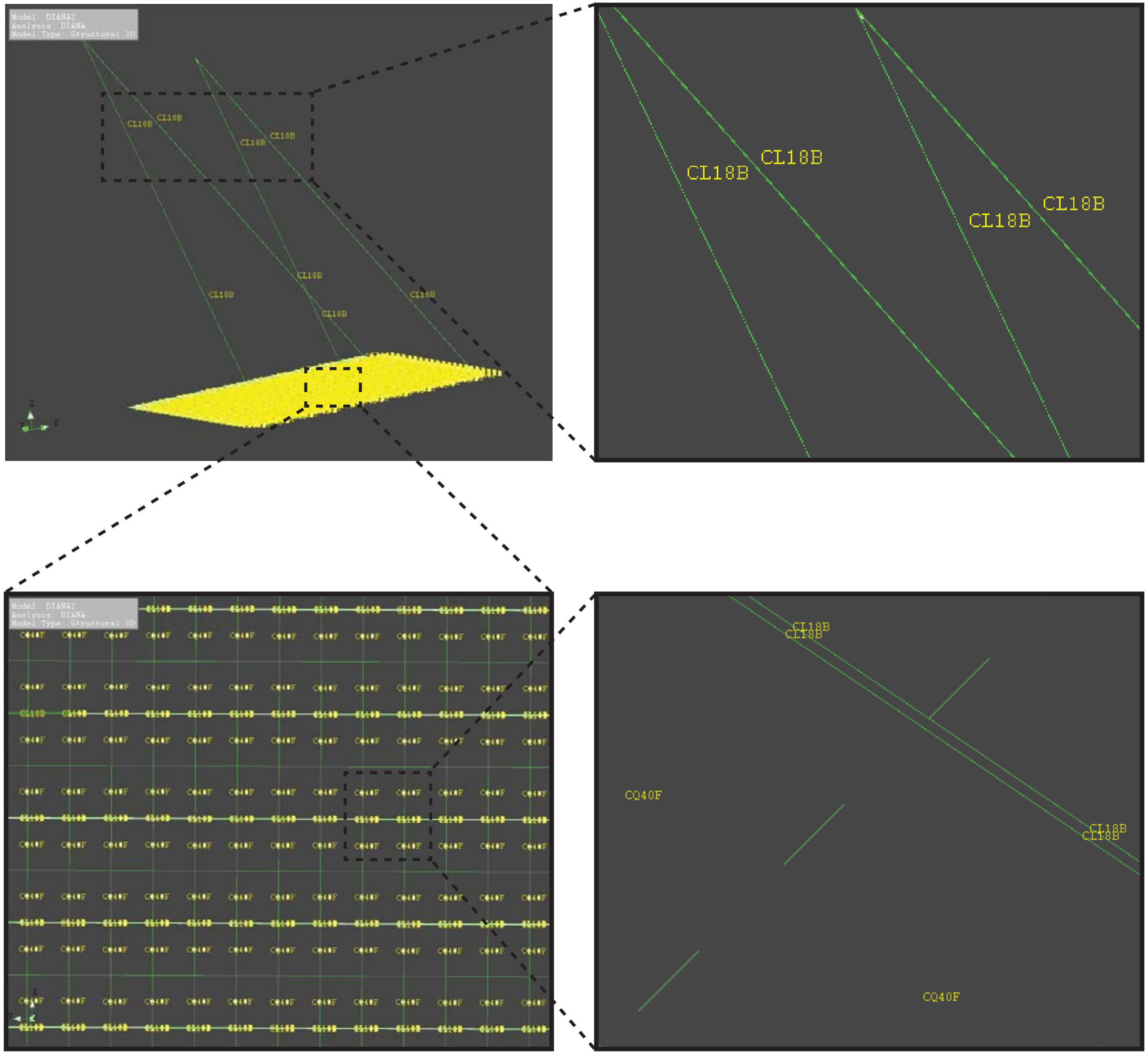
First Sketchup model of the basic element



abstracted model Rhino - input DIANA

Input for the calculations

To make the model ready for calculating a mesh is needed that divides the whole in smaller parts, this affects the accuracy of the output after calculating and makes the analysis much more usable. In this case we used only two types of meshing, a surface type and a beam type. The surface type was used to mesh the panel parts, for this we used CQ8 CQ4040Fcurved CQ8 is the mesh family that applies on surface elements as CQ stands for Curved Quadrilateral and 8 is the number of nodes applied in first instance. In our case this mesh was altered into a 3 by 40 node mesh. For the beams and the tension rod we used the BE3 mesh family type in which the BE stands for beam and 3 for the number of nodes. In the case of the tension rods we left it at that, in the case of the connecting profiles we altered this to 40 to match the panel meshing and make it possible to tie these together.

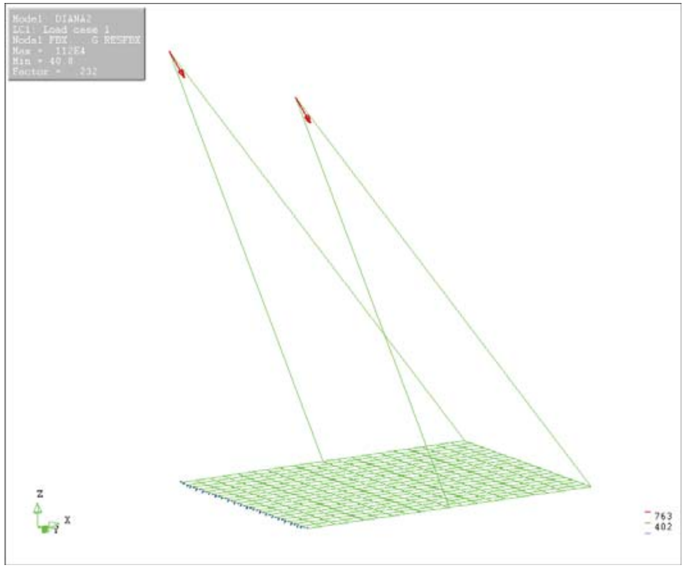


Loads (for use of the different load cases see text above)

To explain the behavior we divided the model into three different load cases. The first load case shows the deadweight of the structure. The materials have been given a certain thickness and the appropriate mass, this combined with the gravity gives the weight. The second shows the expected service load, the loading that takes place under normal use. The third load case shows the behavior of combined loads of case 1 and 2.

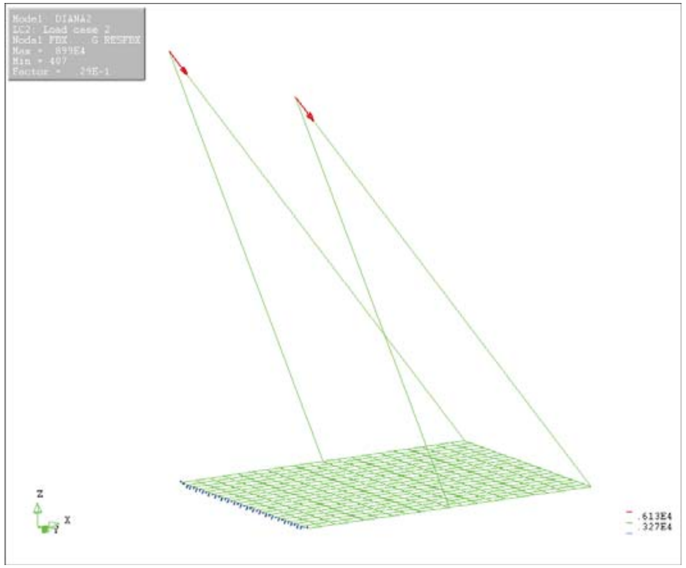
Load case 1

Load case 1 is based upon the dead weight of all the parts, all elements are assigned a thickness and appropriate mass, this combined with gravity results in the dead weight.



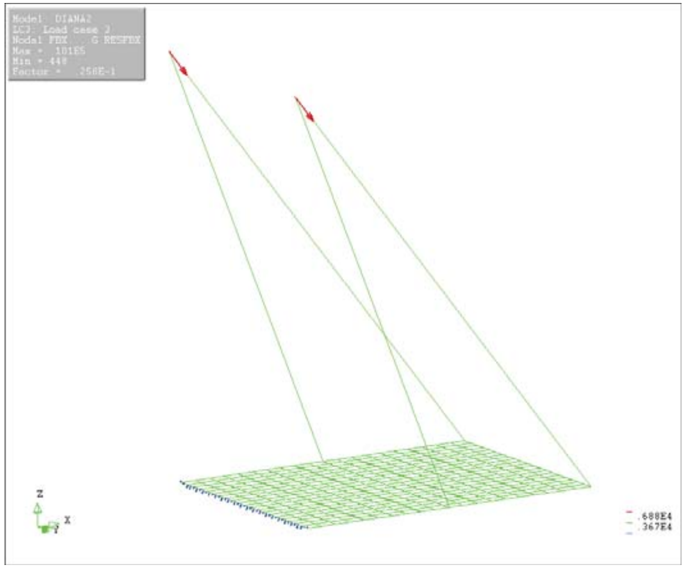
Load case 2

Load case 2 is based upon the service or design loading, the intended weight for the structure to handle.



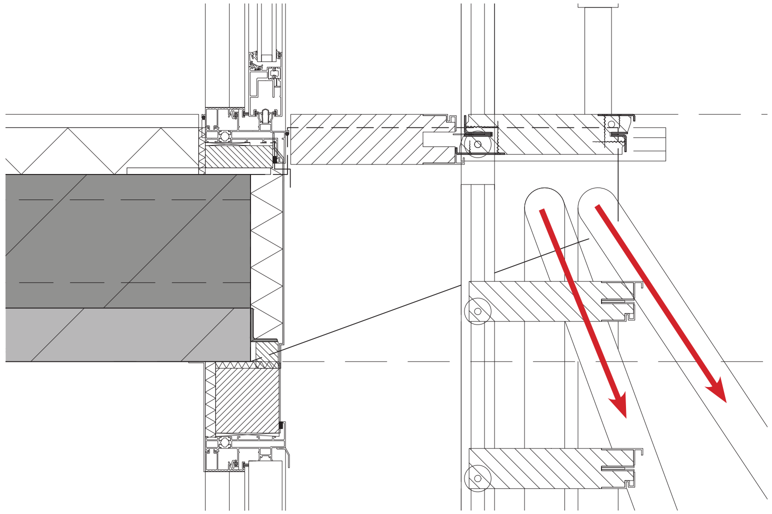
Load case 3

Load case 3 is the combination of deadweight and service load. By looking at the deformation in a combined state it becomes visible if the structure stays whiting the limits.

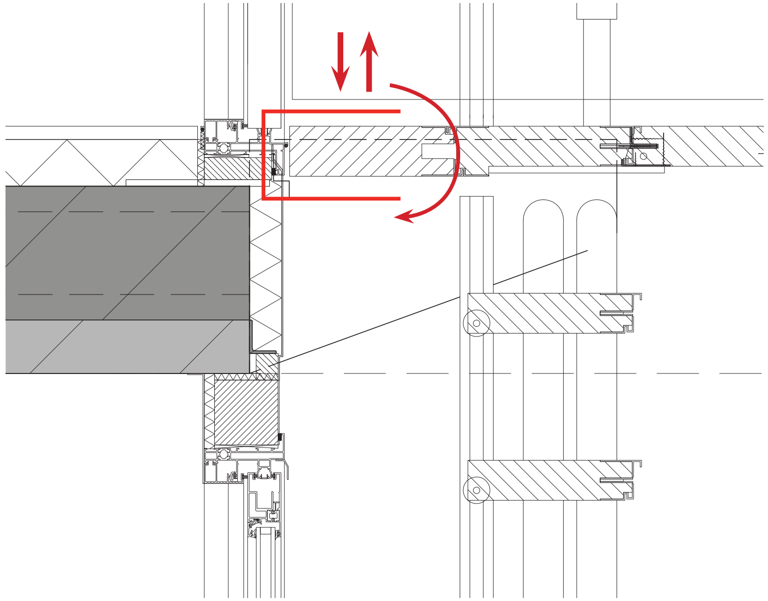


Constraints (incl. boundary conditions)

The constraints that are used in our model are found in the mounting points where the reaction forces are generated. These mounting points theoretically shouldn't move thus we should define their freedom or limit there of. For the mounting of the tension rods (top image) they cant move up down left or right in or out because this would alter the their length and thus influence proper functioning. They can however rotate in the given point without any problems thus this degree of freedom is left free. The other mounting point is the fixed panel spanning the gap between the facade and the rails, when the design is in balcony mode the connecting profiles will lock in this panel thus fixing the balcony in place. This panel is defined as clamped (bottom image) meaning that it cant move in any direction and will generate a momentum if force is applied. The other edges are tied to each other meaning they can only move a little and take no momentum. The tension rods are tied to the panels meaning they can only move in the same direction as these panels.



Hinged, limited degree of freedom



Clamped, no degree of freedom

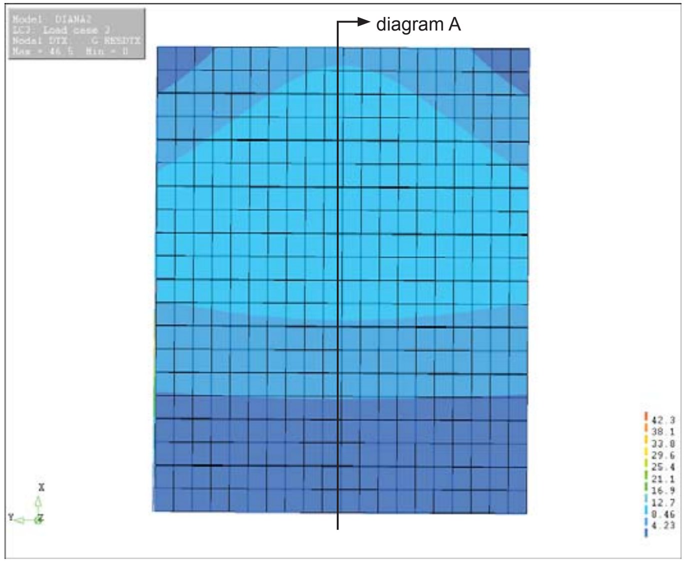
Serviceability

In the following diagrams we present the service state and the limit state in three different values We started with the design loading of 0,8 KN/m2 and raised the design loading with 0,1 KN/m2 each time till we exceeded the maximum allowed deformation.

The maximum bending moment will be: 4 mm/m1

Length balcony: 2.5 m1

The maximum deformation trough the whole length of the balcony will be 10mm.



service state 0,8KN/m2

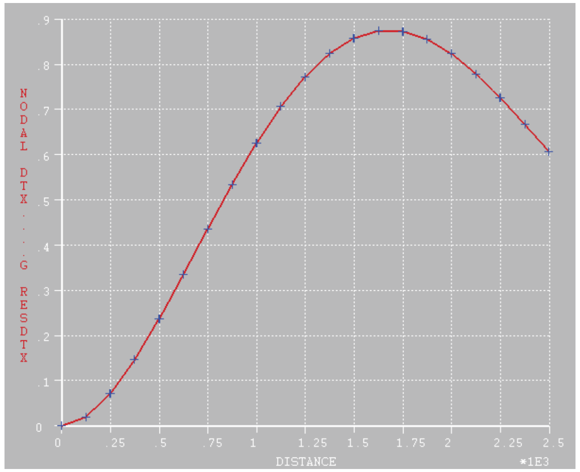
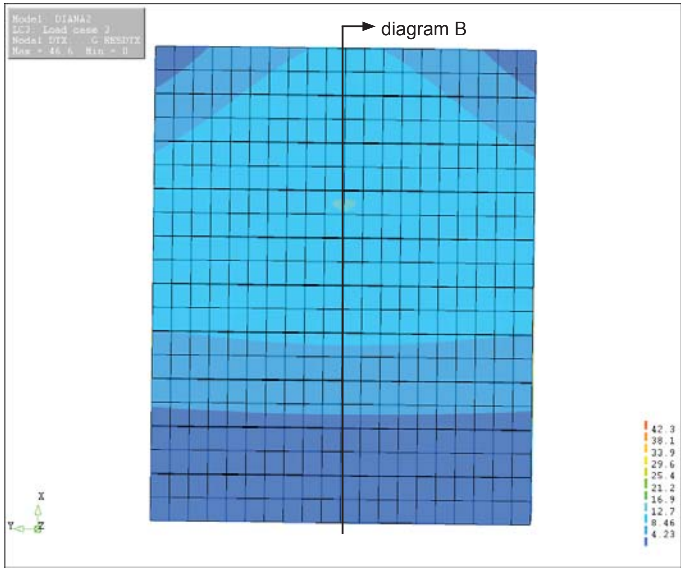


diagram A

Limit state 80KN/m2

Maximum deformations: 8mm



Limit state 0,9KN/m2

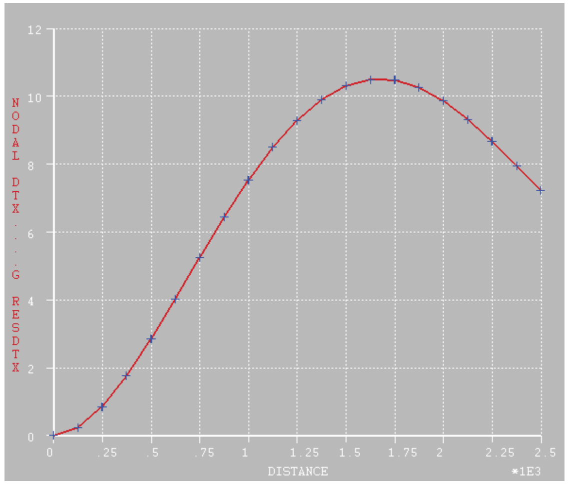


diagram B

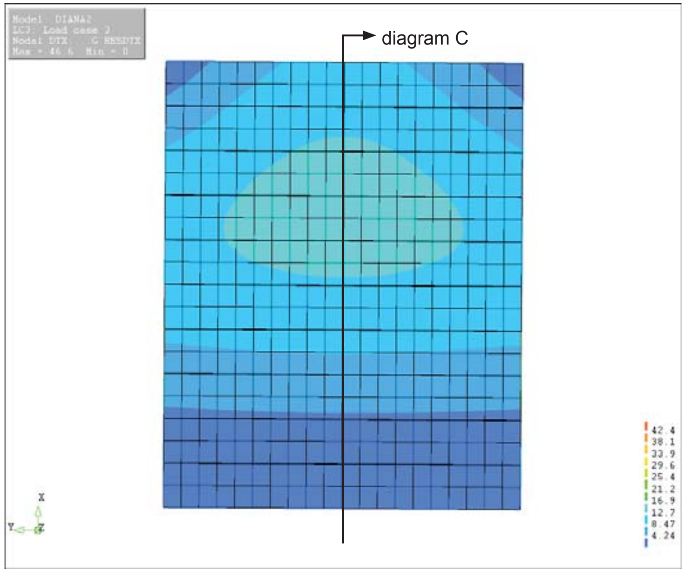
Limit state 90KN/m2

Maximum deformations: 10mm

Ultimate limit state 1 KN/m2

Maximum deformations: 13mm

After analyzing the diagrams we made the conclusion that the balcony will deform too much to be practical if loaded over 1kn/m2, This defines the end of the service state. We did not yet find the loading where catastrophic failure starts as this will probably be due to the failing of one of the connections or hinges that are beyond the scope of Diana.



Ultimate limit state 1KN/m2

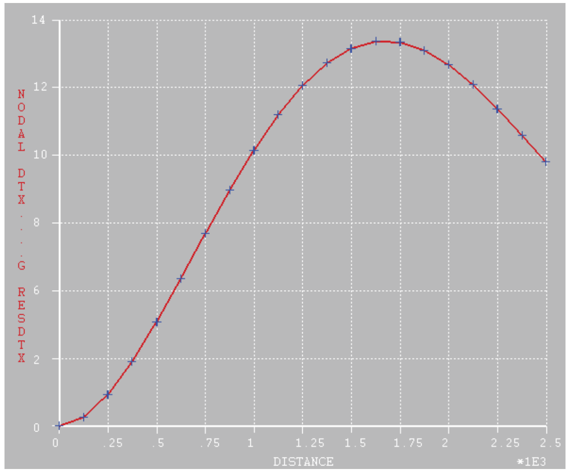


diagram C

Conclusion

The design has proven to be strong enough to do what it was intended to do after calculating in Diana, the deformation stays within bounds and no unexpected results showed. The Diana model we used was working properly for the biggest part that is to say only one set of the tension rods was used by the program although there are two sets. This means that the forces in reality will be spread more evenly than now calculated. The service state however lies really close to the limit state, the end state is not a problem as the deformation will show timely if design forces are exceeded.

To improve more extensive calculation would be needed, not only at the large scale we used now but on the scale of several parts too. Even making the model work with two sets of tension rods would greatly improve the outcome of the calculations.

We think the program is more suitable for buildings and large structures than for the complex design of this balcony as many parts where not looked at in the analysis although these will be affected in the real prototype. In the end the on going development of the design and the insight in the calculation keep following each other in rapid succession as the one influences the other.

Prototype preparation

Prototype cost.

The cost of the prototype can be seen in the spreadsheet right of this column. The fact that we found sopnsoring was key in the actual production of the prototype as the size means that lots of material is needed. We found two sponsors that both contributed by provinding funding for the materials. This meant that we could use new materials for most of the parts and that some of the more expensive parts like the rails could be bought. This saved us lots of time causse otherwise we would have needed to find alternatives. The numbers given in the spreadsheet are our expenses for the models on small scale and the prototype, when the balcony is taken in mass production these numbers will alter big time as different production tecniques will be applied and materials will change and design will be made better and more efficient.

Onkosten tabel folding balcony

datum	onkosten johan	onkosten erik	kosten kees	onkosten diverse	omschrijving	
12-11-2010	€ 10,60				Mdf 12 mm plaat 1200x1200 gezaagd volgens tekening	klaar op maandag 15 in de loop van de middag
15-11-2010	€ 3,40				laseren 4mm perspex normaal ook materiaal a € 5,55 nu alleen laser tijd	
15-11-2010	€ 18,90				houtlijm, boortjes, schroeven 3x30	
20-11-2010		€ 1,00			wielen	
	€ 8,50				reader architecturals history modernity	
			€ 75,00		rails	
			€ 333,80		staal plaat en profielen	
				€ 100,00	hout	
14-1-2011	€ 2,40	€ 17,00 poster + A0 zwart wit			repro kosten	
	€ 13,00 foam	€ 3,00 dive a3				
		€ 4,00			dvd's + verzending	
	€ 13,00 ketting				tandwielen	
					fiets ketting	
15-1-2011	€ 11,50 gamma				klein materiaal, schroeven	
13-1-2011			€ 20,00		zetten staal	
	€ 30,00 benzine					

budget	€ 775,00
uitgegeven	€ 665,10
resterend	€ 109,90

totaal Johan	totaal erik	totaal	totaal
€ 111,30	€ 25,00	€ 428,80	€ 100,00

tu betaald	€ 250,00	
betalen	€ 178,80	aan kees

totaal opgeteld € 665,10

€ 250,00	tu	
€ 275,00	hurks	
€ 250,00	sorba	ontvangen

budget is € 775,00

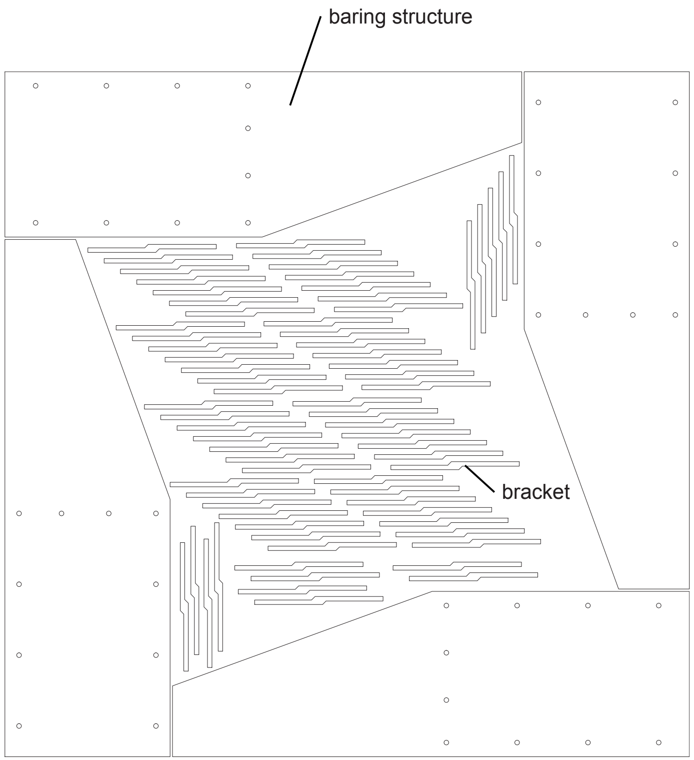
List of used drawings

drawing code	subject	scale	size	phase	status	date	changed	comments
BT-4	drawing list		A3	PD	final	03-01-2011		
BT-4-01	overview		A3	PD	final	03-01-2011		
BT-01-01	panel elaboration	1:1	A3	PD	final	03-01-2011		
BT-01-02	panel elaboration	1:1	A3	PD	final	03-01-2011		
BT-01-03	panel elaboration	1:1	A3	PD	final	03-01-2011		
BT-01-04	panel elaboration	1:1	A3	PD	final	03-01-2011		
BT-01-05	panel elaboration	1:1	A3	PD	final	03-01-2011		
BT-01-06	panel elaboration	1:1	A3	PD	final	03-01-2011		
BT-01-07	panel elaboration	1:1	A3	PD	final	03-01-2011		
BT-01-08	panel elaboration	1:1	A3	PD	final	03-01-2011		
BT-01-09	panel elaboration	1:5	A3	PD	final	03-01-2011		
BT-4-02	overview		A3	PD	final	03-01-2011		
BT-02-01	primary construction elements	1:20	A3	PD	final	03-01-2011		
BT-02-01.1	primary construction elements	1:20	A3	PD	final	03-01-2011		
BT-02-02	primary construction elements	1:5	A3	PD	final	03-01-2011		
BT-02-03	primary construction elements	1:5	A3	PD	final	03-01-2011		
BT-02-04	primary construction elements	1:1	A3	PD	final	03-01-2011		
BT-02-05	primary construction elements	1:1	A3	PD	final	03-01-2011		
BT-02-06	primary construction elements	1:20	A3	PD	final	03-01-2011		
BT-05-001	project overview	1:20	A0	PD	final	03-01-2011		

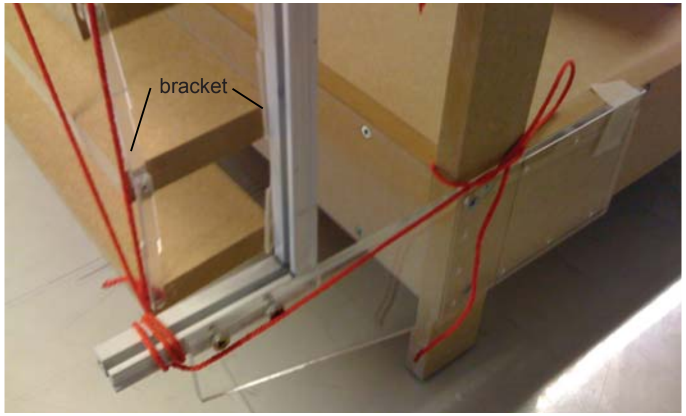
Rapid prototyping

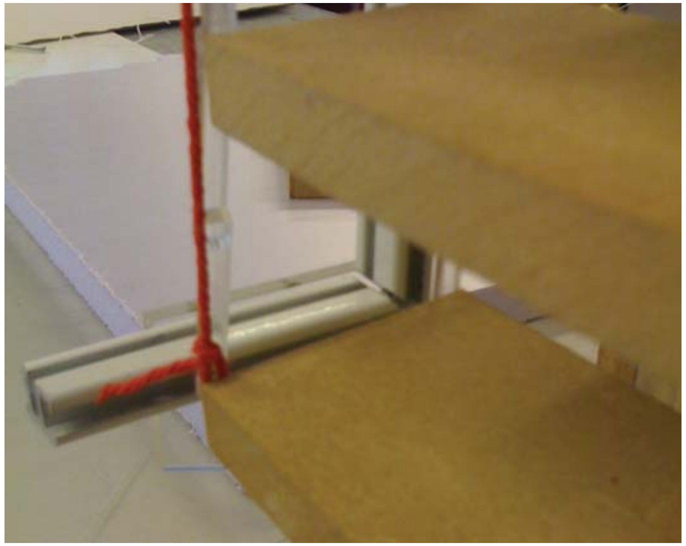
1:5 model

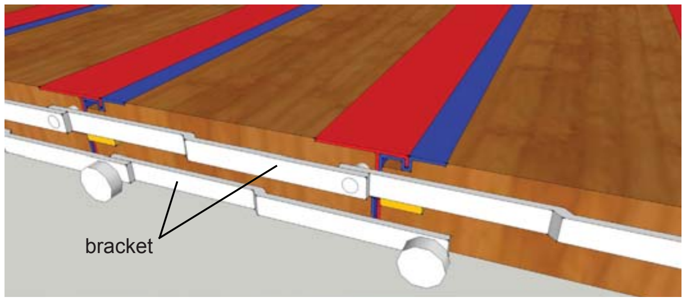
We only used the Rapid prototyping on this 1:5 model. The brackets on the end grain of the louvre parts where made with the laser cutter. These are very thin so this was the only solution. In the 1:1 model we should cast them in iron or use a drop forgde technique but we did not have the money or the need to do that for this one model.

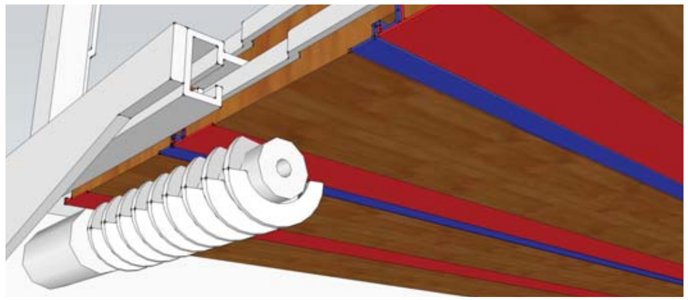


laser cut drawing









Prototype build

On this page you find a few overall pictures of the 1:1 model. Again you see the brackets and on the picture right you can see that one bracket is missing. This is because the brackets where to week to hold the weight and pressure of the other louvre parts. We made them of 2mm steel and we think that if we could cast them in an thicker material an maybe just change the form a bit it should be strong enough the survive the high forces.

There are some parts where we used the fully automatic C&C milling machine to make sure the positions of the holes where exactly on the right spot.

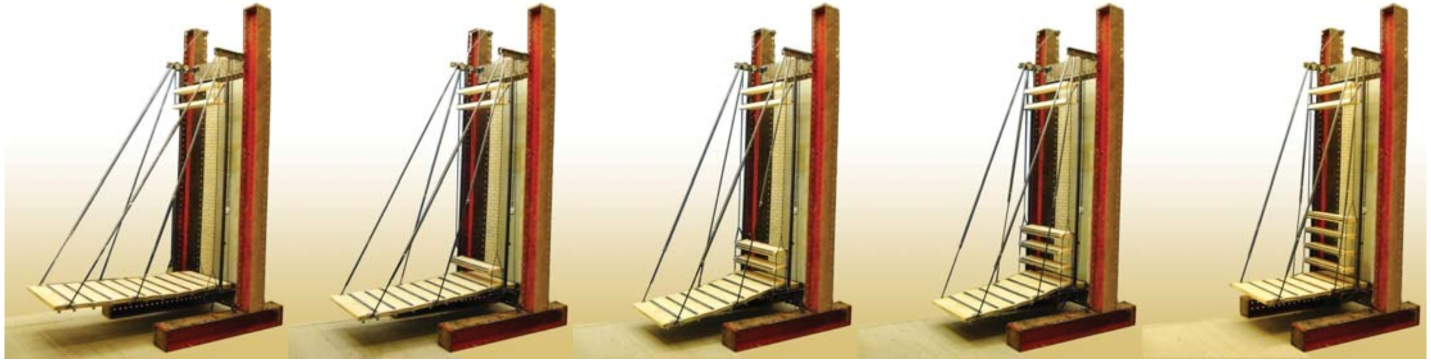




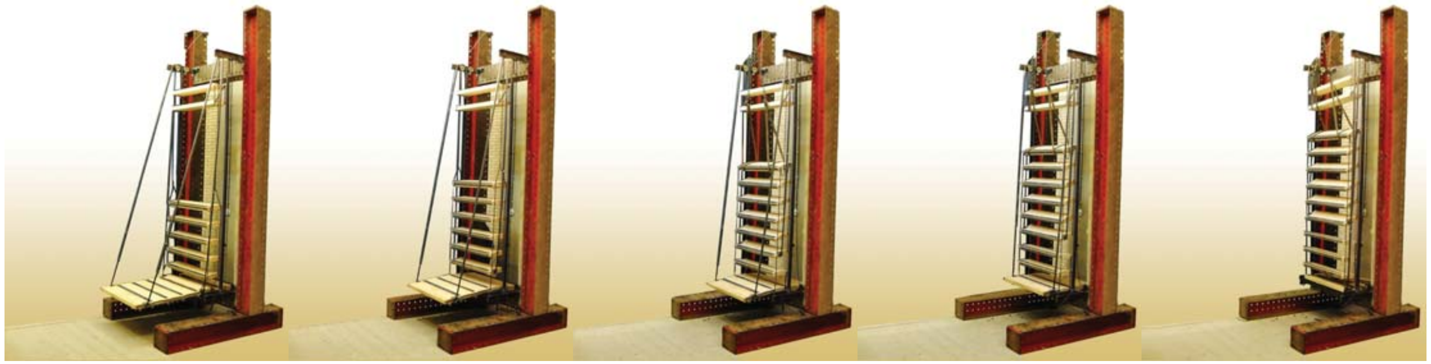


Sponsorship and the outside sun shading balcony in final form

sorba shaping architecture



hurks geveltechniek



Product improvements

Mass production techniques

The prototype was made completely by hand and all parts where made custom. When the design is to be produced in larger numbers this will not feasible. To make the parts en mass some design changes are needed. For instance the panels could be made from extruded aluminium to reduce their weight and get a ridged element with a clean connecting edge. Alternative could be to make the panels in a composite version. The rails could be improved to house more than just the bearings of the panels, they can be used to cover the chain that drives the system. The rods that connect the panels now are made from folded sheet metal, if these are forged or cast they will be much stronger and faster to produce.

Material choice

To make the prototype we used the materials that where easy to obtain and process. The wooden panels used would be unnecessary heavy, to make these lighter it would be a good idea to use fiber reinforced plastic for the outer surfaces and a ridged foam core. The composite that is made in this way is strong enough to take the forces and wont deform if walked up on but much lighter and form constant. The rails we used is a galvanized steel profile, when made from aluminium this part would be lots lighter for the construction and is not likely to corrode in a catastrophic way.

General

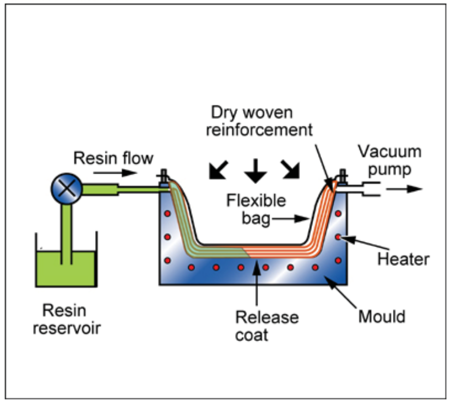
Tradenames

VARTM, SCRIMP (Seeman composite resin infusion molding process), RIFT (resin infusion under flexible tooling) VARI (vacuum assisted resin injection), VRTM (vacuum resin transfer molding) RIRM (resin injection re-circulation molding), VIMP (vacuum injection molding process).

The process

VACUUM ASSISTED RESIN TRANSFER MOLDING (VARTM) is a low-cost tooling way of manufacturing large complex shapes of composite materials. Reinforcement is placed in the mold in the form of layers of dry, woven fabric. This is covered by a peel ply and the whole lot is vacuum bagged. Resin is released and sucked into the bag by the vacuum, flowing through and impregnating the fabric, which is then cured.

Process schematic



Design result

Impact of design

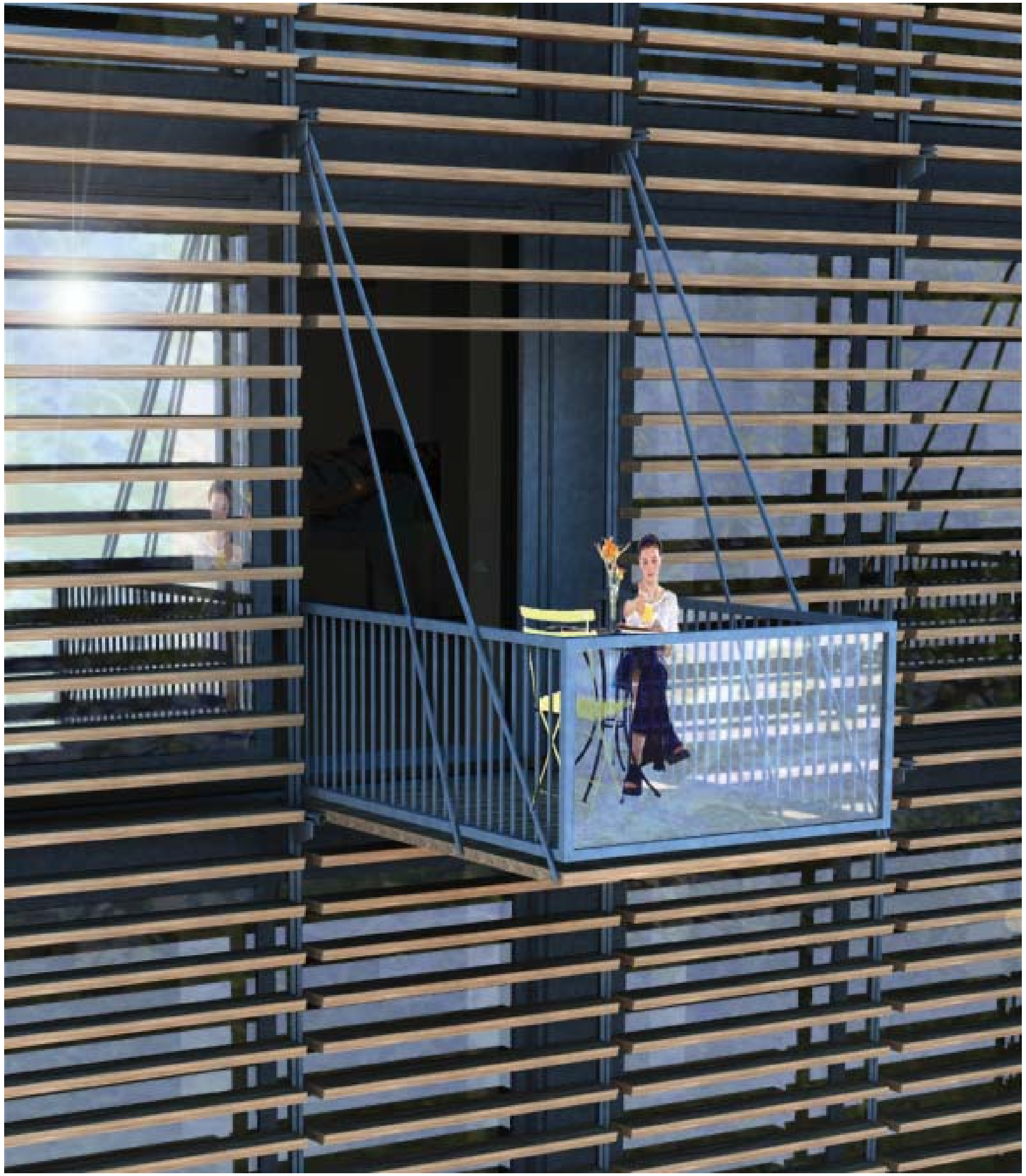
The design as build by us is the result of six months of thinking and looking around. Just as we looked at other designs and solutions the people that will see our work will be influenced and might take parts of it to use in their work. The basic elements might not be very use full but the innovations can be the key in solving delicate and intriguing problems. Just as we discovered the bigger solution is often made up from lots of smaller finds and combining these in a smart way. Although the design might not be revolutionary in the world of architecture we hope that it will be contributing in a positive way and might inspire other designers in their quest for the ultimate design.

Feasibility

The design was build by us in the building technology laboratory in the form of a full size prototype. We learned that much of the design was working the way we thought it would work, and that there where parts that where not working at all. If the design would be mass produced than the material needs to be altered as described earlier in this booklet this will have great effect on the design. Further more the drive mechanism would need to be redesigned, the movement is good but the way it is powered should be automated by means of an electrical motor and switches. The tension rods need to be supplemented with either counterweights or tension springs to take the load of the balcony in an evenly distributed way. Than finally the most intriguing part the interlocking of the panels. This mechanism proved to be working good but the dimensions that we used must be made bigger to prevent bending, the surrounding metal needs to be a bit thicker and more space is needed to house the elements without them getting jammed. So al together it is quite hard to tell if the design is feasible as we discovered that many small and big elements still need to be redesigned and we can not tell in advance if this is going to work.

Conclusion

The designing and building of a part of a facade on this scale was something completely new to both of us. During the semester we learned lots of new things and found new ways to solve problems. The complete process from scratch until final produced product was a great experience that will last our complete life. Thanks to all that helped us though. The balcony that was designed might never actual be mounted on any building but to us this is irrelevant. We where given precious knowledge on many details that in a normal situaton remain hidden to the designer as he almost never gets to work hands on. we enjoyed the whole to the max and would like to recomend every building technology student to do the same.



List of Figures

The figures on page 13 till the last page are fully made by Johan Bogaart & Erik van der Thiel, Msc2