MASTEROPPGAVE
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Compact living: Solutions in shaped wood veneer laminate

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OG AKERSHUS

0.1 Introduction

In this project report I have documented my master project. The report starts off with my initial project description, which includes my research & design questions and project theme.

I will go through my research and experimentation of my main material and manufacturing process; Shaped wood veneer laminates and my initial research of “compact living” what the defines the term. How and why we should design for it.

Further more I will use my initial research and experiments to create a scenario experiment where I observe people as they are presented a compact living scenario, which they must engaged themselves in and solve in a 1:1 scale.

This experiment and other experiments will also be documented with time-lapse videos; they will give a more in-depth view of the experiments and the results. The videos are on a DVD, which can be found in the back of this report.

The results of my research and experiments are combined into a design process where I create a modular furniture system. This system tries to achieve the features identified in the research and solves the issues that arise in a compact living setting.

0.2 Initial Project Description

Project theme

The theme of the project will be “compact living” furniture. Which I believe will be several modular furniture pieces. I will also be using-Shaped wood veneer as my main material and manufacturing process. It is in this material I will do most of my research. I will research the limitations of the material and the manufacturing process as well as the advantages. These experiments will lead to furniture solutions for compact living.

Motivation

We are living in smaller and smaller spaces as the population of the world continues to grow. We need furniture that we can adapt to our living space, furniture that has more than one function.

Based on my personal experiences and interests I feel there is a hole in the market for some real furniture for compact living. Also I have been thinking about doing a Furniture project for a long time. It is the one thing that I have not done yet in my design studies. But it is an area, which I find increasingly interesting to try to work with.

While we are more and more conscious on how the things we have in our home represents ourselves and too who we identify ourselves with. This consciousness doesn’t only extend to the aesthetic and function of the item. The materials that the furniture is made of and how it was made, finally who made it and where.

Research Question

How can modular furniture solve the problems that arise with in compact living today and in the future?

How are these furniture solutions possible to create with pure and recyclable materials, while being esthetically pleasing?

Possible outcomes (which can change)

Modular furniture designed for compact living. A range of furniture or one single piece/system.

1.1 Wood Lamnination

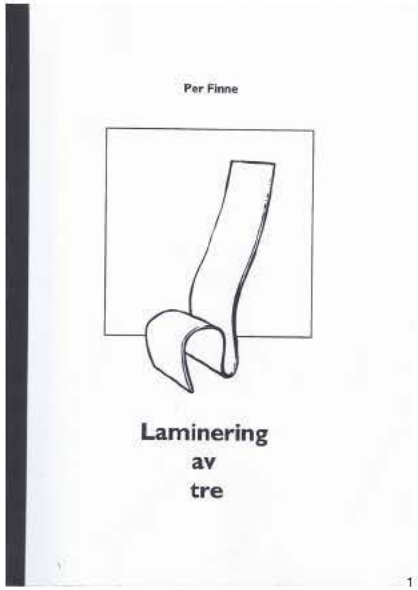
For my master project I choose laminated wood veneer as my primary material. I have always admired the look and feel of bent wood veneer. Using this material to produce furniture solutions for compact living where my primary motivation going into this project.

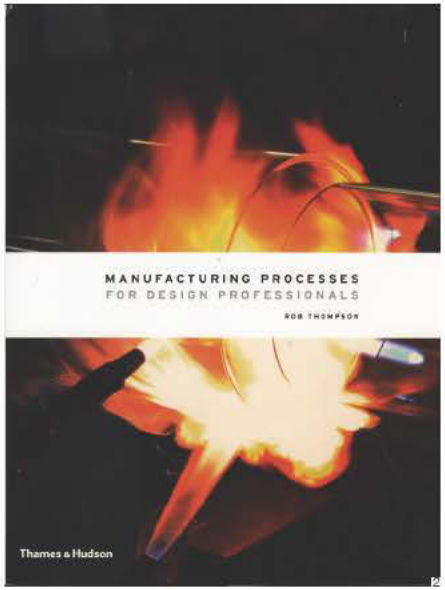
There are many forms and techniques for lamenting wood. However I have concentrated on laminating wood veneer and shaping this lamination through the use of moulds and pressure.

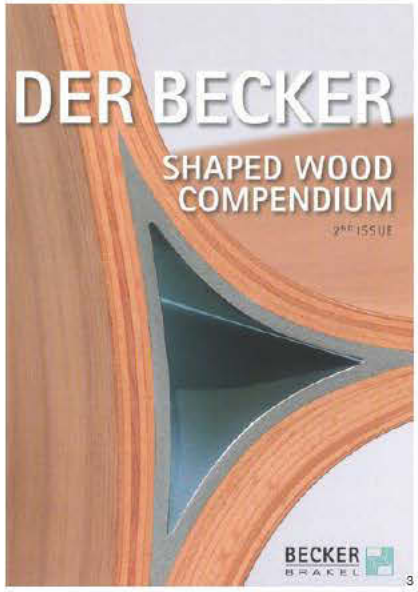
To understand the process and techniques involved in this process I research several books.

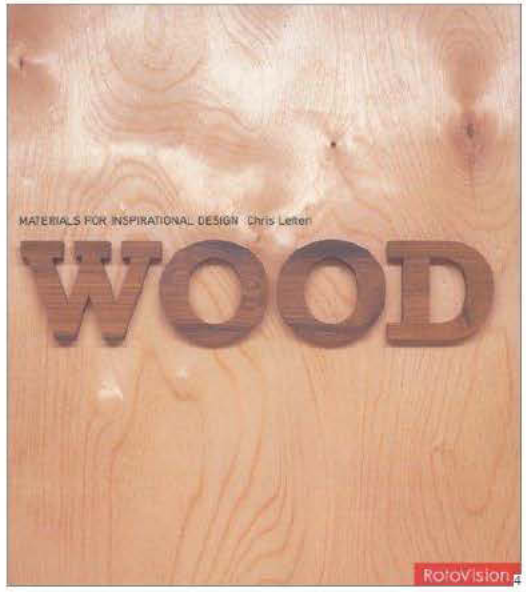
- Laminering av tre
- Manufacturing process for design proffesionals
- Der Becker Shapedwood compendium,
- Wood

These books have extensive information on the techniques and process involved in producing Laminated wood on an industrial scale and on a small scale.
I will go through a short combined summary of the these process both on the industrial scale and the small scale which I used in my material experimentation









1. Laminering av tre, Per Finne, Institutt for industridesign SHKS
2: Manufacturing process For design proffesionals, Rob Thompson, Thames & Hudson, 2007, London
3: Der Becker Shapedwood compendium, 2nd issue, Becker Brakel, 2010, Brackel
4: Wood, Chris Lefteri,Rotovision, 2005, East Sussex

1.2 Wood Veneer

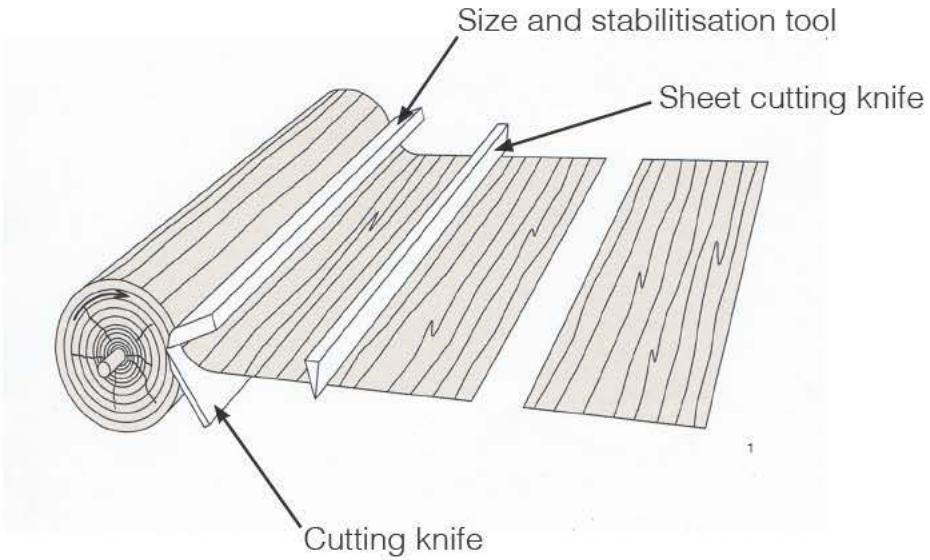
The basic material in laminating wood is wood veneer. Veneer is produced by three different methods which creates veneer with different properties

Peeling

The Wood trunk is softened up in a bath of water and steam. The trunk is then rotated while a knife cutes sheets of veneer of the trunk's side, while the thickness of the veneer is controlled by a tool which sits perpendicular to the knife. The picture to the left illustrates this process.

The peeled sheet can in theory be several meters long, but it is usually cut into sections depending on what it is going to be used for. Thin hairline cracks appear on the side that faces the knife this is referred to as the broken side and should always face inward in a laminate of veneers.

Peeled veneer is usually used in making the big sheets of plywood commonly used in all manner of construction.



1:illustration from: Der Becker Shapedwood compendium, 2nd issue, Becker Brakel, 2010, Brackel, page 122

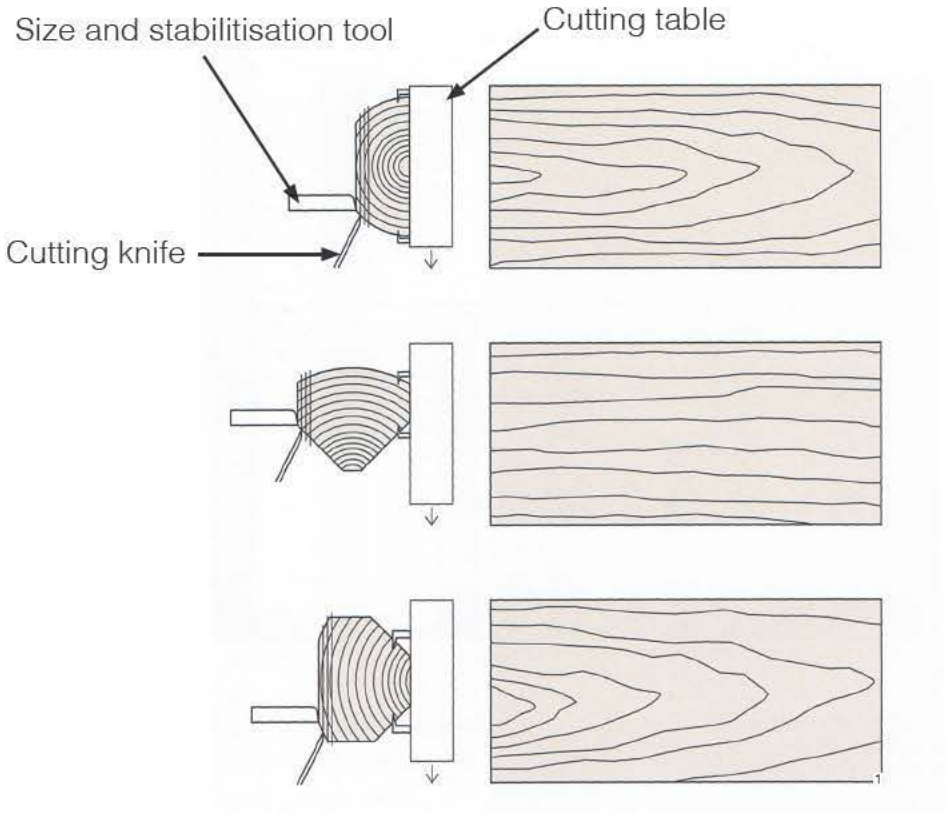
Slicing

This method is used mostly to create surface veneer. This type of veneer is used to create desirable look on the finished product.

The wood trunk is clamped onto a cutting table and a broad knife slice of sheets of veneer. Bye rotating the log or changing the cutting direction, different patterns of wood grain can be achieved. The picture to the right illustrates this process.

Sawing

This is the oldest method. This is hardly used in modern production of wood veneer as it produces a lot of vast, due to the thickness of the sawing blade.



1:illustration from: Der Becker Shapedwood compendium, 2nd issue, Becker Brakel, 2010, Brackel, page 126

1.3 Types of Wood Veneer

All types of wood can be used to create veneer. However the Furniture industry in Norway and Europe uses mostly Beech veneer for laminating. In Norway we use 90% beech form Denmark, Germany or France and the last 10% is mostly Birch from Finland.

Beech

Beech is the tree species that has the best abilities when it comes to making veneer and then later shaping and lamenting it. Because of this most shaped wood laminates has a core of peeled beech veneer with a decorative outer veneer that can be another type of veneer.

Beech wood is especially homogenous because of its cell structure where the wood pores are of the same diameter and is evenly distributed in the growth rings. This gives it an even and humongous look. Beech is also a strong and heavy wood. Its weight is similar to that of Oak and it is one of the toughest and most solid woods. A strength comparisons chart for beech and other hard wood are shown to the right.

Beech is stronger than oak when it comes to bending, shearing, shattering, torsion and splitting.
This properties makes it perfect for furniture.

Type	Pull-strength*	Pressure-strength*	Bending-strength*	Shear-strength*	Hardness*
Maple	82	49	95	9	67
Oak	110	52	95	11,5	69
Ash	130	50	05	3	76
Beech	135	60	120	10	78

*in N/mm²

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1. Beech tree. http://upload.wikimedia.org/wikipedia/commons/5/5c/Ringvebeech-Trondheim.jpg, 07/05/2012
2. Compariont chart from: Der Becker Shapedwood compendium, 2nd issue, Becker Brakel, 2010, Brackel, page 122

Beech wood is also very flexible after it is steamed and will not return to its original shape.

However there are several drawbacks with beech wood. It will shrink allot and this has to be taken into consideration when designing with Beech.

Untreated beech is also very sceptical to fungi infestation, because of these it is not a wood that can bee used outside.

It is the homogenous nature of the beech wood, which makes it such good wood for formed plywood. Combined with its other characteristics. A close up picture of Beech wood grain can bee seen to the right.

1. Beech wood grain close up. Photo taken by the author, 2012

Birch

Birch is the second most used tree species in laminated furniture in Norway. Birch is lighter both in colour and weight than beech. Most plywood sheets are made out of birch veneer.

Birch has a more desirable look to its surface than Beech and while it has some of the same characteristic as beech when it comes to laminating and shaping plywood. A close up picture of Birch wood grain can bee seen to the right.


1

Fuma

Fuma or bendy-ply this is a type of veneer that we use in the workshop to create mock-ups and moulds. IT is made up of three sheets of veneer from the Fuma or Ceibia tree that grows in West Africa. Fuma grows extremely quick, which means that it is a light and very flexible wood. However it is not very strong. apicture


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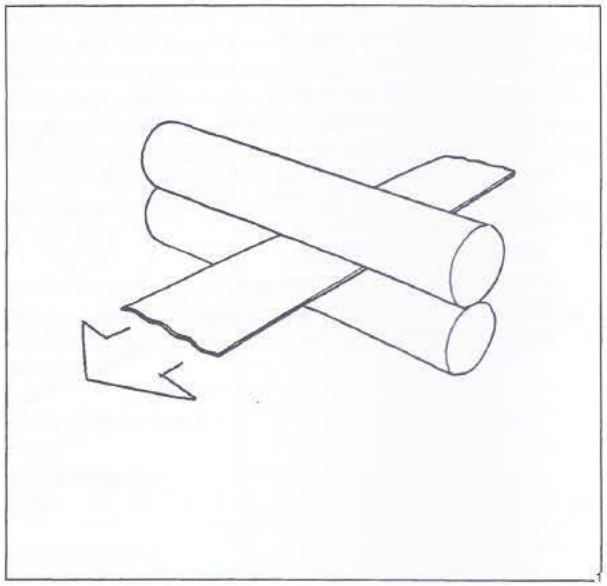
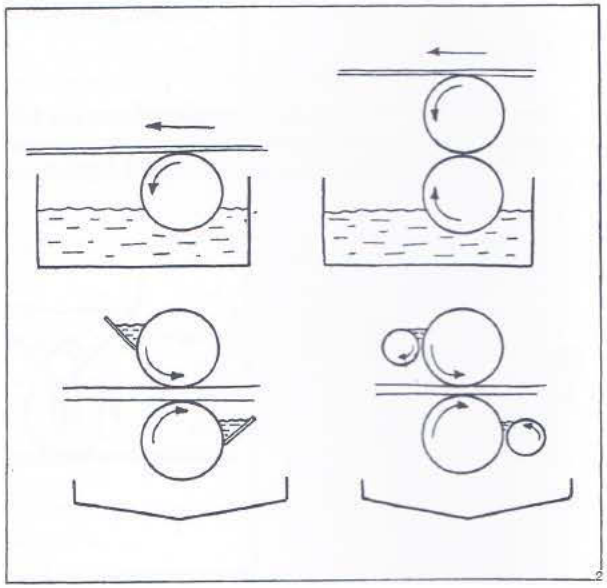
1. Birch wood grain close up. Photo taken by the author, 2012
2. Fuma, http://www.winwood-products.com/images/flexible-plywood-lge.jpg 09/05/2012

1.4 Veneer laminating process and techniques

The basic principles of laminating veneer are the same in industrial scale and small-scale production. Sheets of veneer are coated with glue and pressed into a mould under high pressure or vacuum.

The wood laminate is left in the mould until the glue has cured and the molded laminat can be removed. Depending on the glue type used it will continue to cure after being removed from the mould. The laminate's edges are then trimmed.





The industrial process

The veneer sheets are coated with glue in a machine that uses big rollers to apply the glue evenly on both sides of the veneer except for the two out layers (image 1). Diffrent types of glue rolling techinuis are shod on image 2.
The bonded veneer is then taken to the mould (image 3) . They are forced into the mould under pressure (image 4-5), depending on the type of wood in the veener this pressuere can vary from 8kg/cm^3 to 20kg/cm^3.

To aid the curing process of the glue, the mould can be heated either electrically or by using a hollow mould with hot liquid circulating inside the moulded. When accelerated curing through heat is used, the laminated can be almost completely cured after just 15 minutes. This curing process usually takes 24 hours when no heat is applied to the mould.

1. Glue rollers: Laminering av tre, Per Finne, Institutt for industridesign SHKS, page 70 page 122
2. Glue roller variations: Laminering av tre, Per Finne, Institutt for industridesign SHKS, page 70
3,4,5. Press moulding veneer: Der Becker Shapedwood compendium, 2nd issue, Becker Brakel, 2010, Brackel,

Spring back

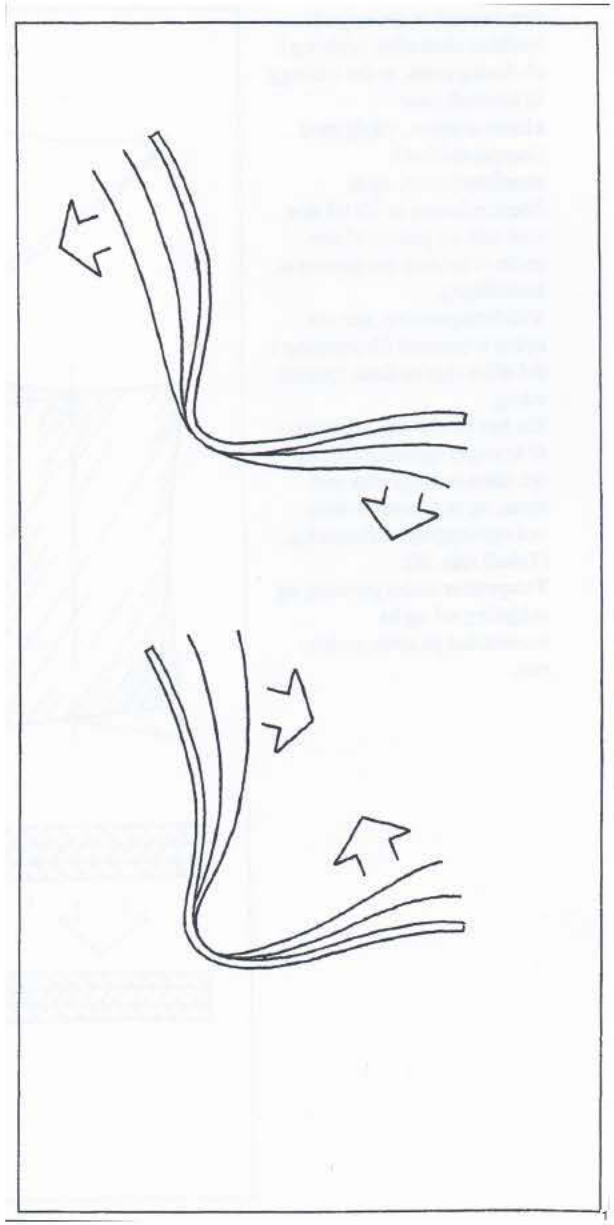
However the "spring-back" in heat cured laminated is greater than in cold cured laminates. So heat cured laminates are fitted onto a jig to keep their shape until the have fully cured.

Spring back is a phenomenon that happens to all bent wood. The wood deforms because of moister imbalance between it and its surrounding environment.

Spring back can occur between 1 and 4 weeks after the wood is shaped. If the wood is to moist compared to it environment it will dry out to balance itself and it will spring in or shrink. If the wood is to dry it will do the opposite and spring back. (image 1.)

This phenomenon can be countered in a number of ways first the wood should have a moister content of about 10% while it is being shaped. Secondly by crossing each layer of veneer in different direction compared to its grain will make the wood straighten out itself. Third by knowing that the phenomenon will occur one can take it into account and design for it.

When the laminate is fully cured and the "spring back" has occurred it is taken to bee machined and trimmed by a set of CNC machines, which shapes it into the finished part. (image 2)



1. Spring Back: Laminering av tre, Per Finne, Institutt for industridesign SHKS, page 15
2. CNC machining: Der Becker Shapedwood compendium, 2nd issue, Becker Brakel, 2010, Brackel, page 137

The small-scale process

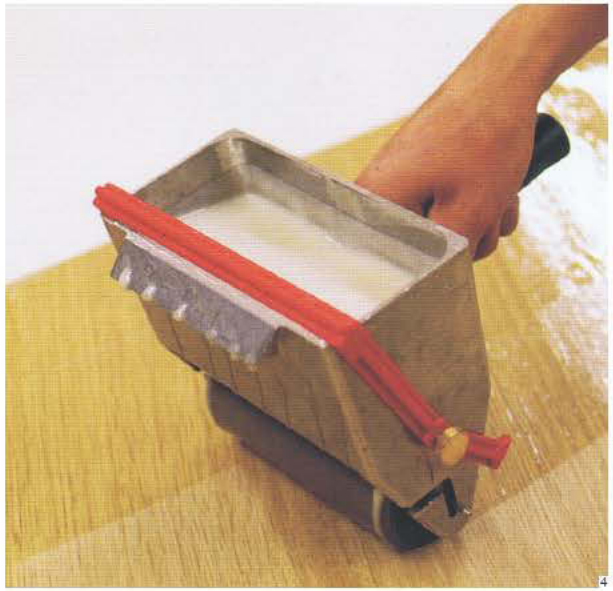
This process is what small furniture business and model makers usually use. There are several different techniques within these processes, but they can be divvied in to two major areas.

The multi-part mould and the single-part mould

Common for both methods is that the glue is usually distributed evenly by using a hand-operated roller (image 4). The most common glue to use is a Urea Glue used this is a chemically cured glue where the curing process starts when a hardener is mixed into the glue. This glue has good water and heat resistant and is long lasting. For small-scale production a powder form of this glue is used. The glue becomes active when water is added

The multi-part mould technique

This technique requires an inner and outer mould or a male and female mould. The veneer are sandwiched between the moulds (image 1), pressure is then applied manually or through a hydraulic press (image 2). The laminate is left in the mould to cure for several hours up to 24 depending on the shape and wood used (image 3). This is the simplest and cheapest way of producing shaped veneer laminates. When the part is cured it is removed and the edges are trimmed.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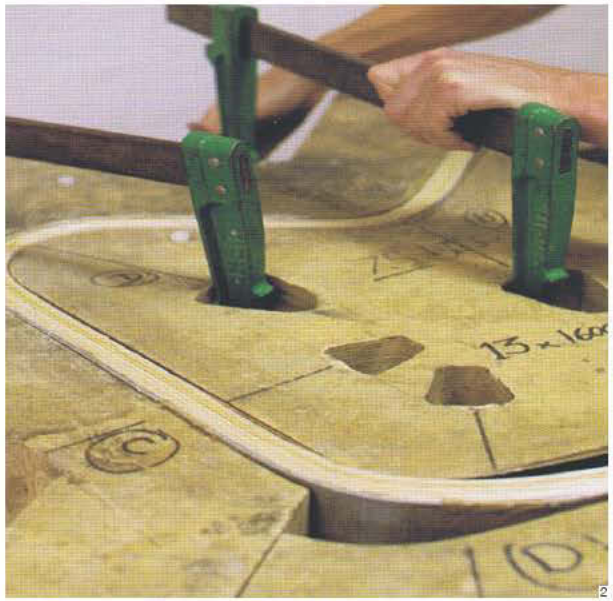
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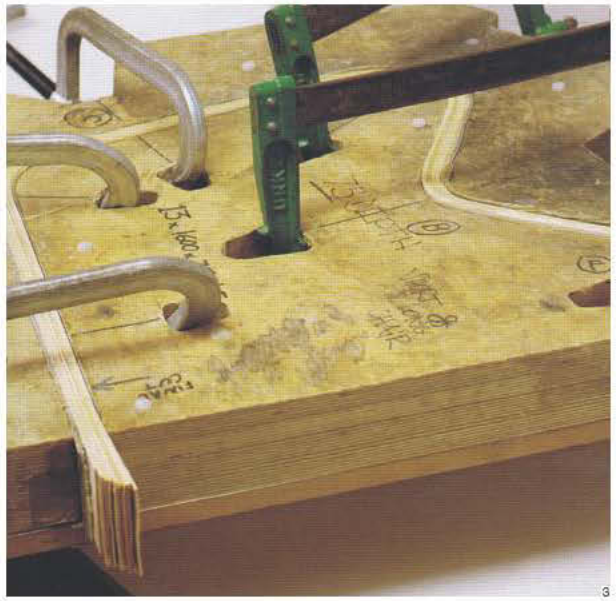
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1,2,3. Cold press multi-part moulds: Manufacturing process For design proffesionals, Rob Thompson, Thames & Hudson, 2007, London. page 193
Hudson, 2007, London. page 195
4. Glue roller: Manufacturing process For design proffesionals, Rob Thompson, Thames &

The single-part mould technique

In this process an only one side of the mould is required. The veneer is balanced onto the mould (image 1), then they are either forced to take the shape of the mould by using multiple clamps (image 4) or a vacuum table/bag.

The vacuum forces a heavy-duty rubber sheet over the veneer, which forces it onto the mould. (Image 2) Heat can be applied in this process to speed up the curing time. (Image 2 and 3)

Without heat the curing takes 24 hours.
This technique offers a greater flexibility in mould design to the manufacture, as only a single mould is required to create a laminate.

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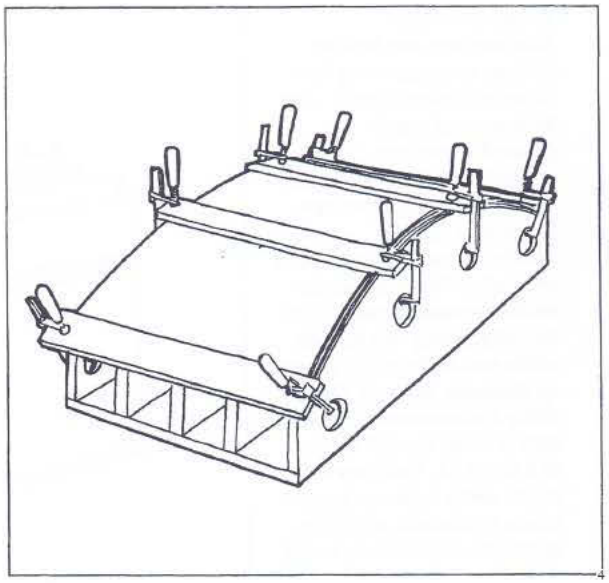

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1,2,3. Vacuumed singel-part moulds: Manufacturing process For design proffesionals, Rob Thompson, Thames & Hudson, 2007, London. page 197
1. Spring Back: Laminering av tre, Per Finne, Institutt for industridesign SHKS, page 73

1.5 Minimum raidus test

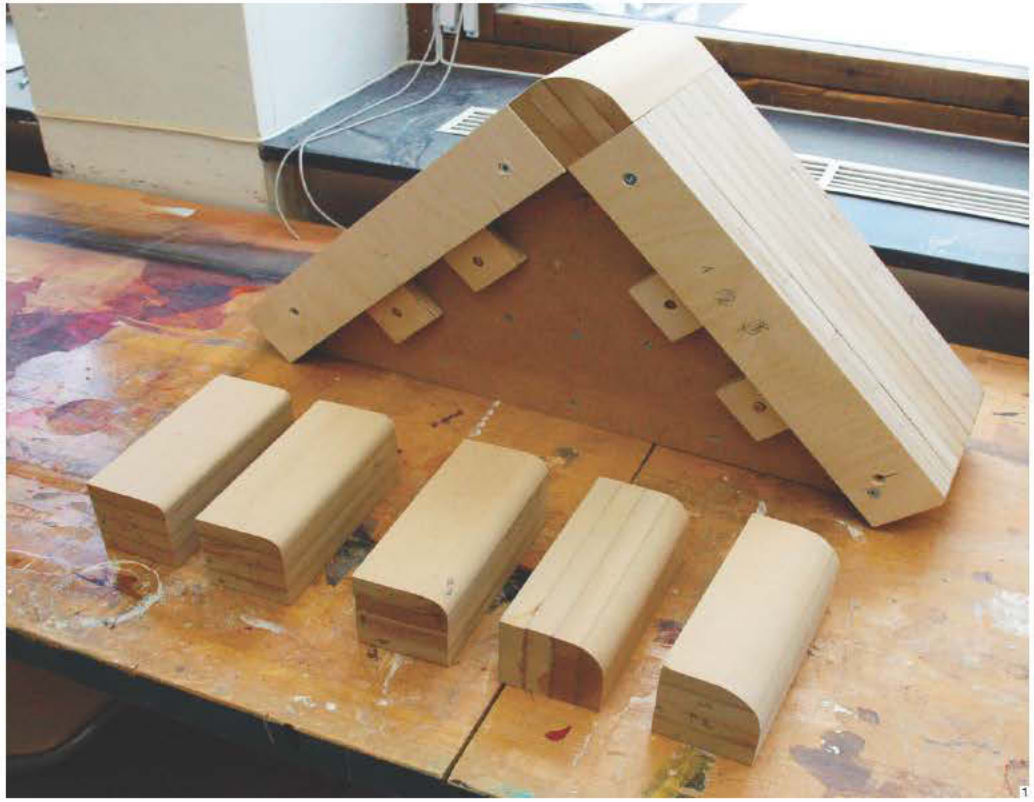
When I started this project I had never tried to laminate veneer before, I decide I would to an experiment to see how small radiuses I could create by laminating different types of veneer.

At the same time I would acquire the experiences of working with the single mould technique and learn all the little tricks there is in veneer laminating.

Fuma tests

I did a series of laminates using Bendy-ply or Fuma as the core and Beech as the outer veneer going from 3cm radius on 90 degrees bend to 1cm radius.
I constructed a mould where I could interchange the top part for different radiuses (image 1). The radius which I tested where 4cm, 3cm, 2.5cm, 2cm, 1.5cm, 1cm.

On the DVD that can be found in the back of this report there is a video showing a time-lapse with more in-depth comments on the processes that I went through.



1. Test mould with insert radius pices: Photo taken by the author, 2012

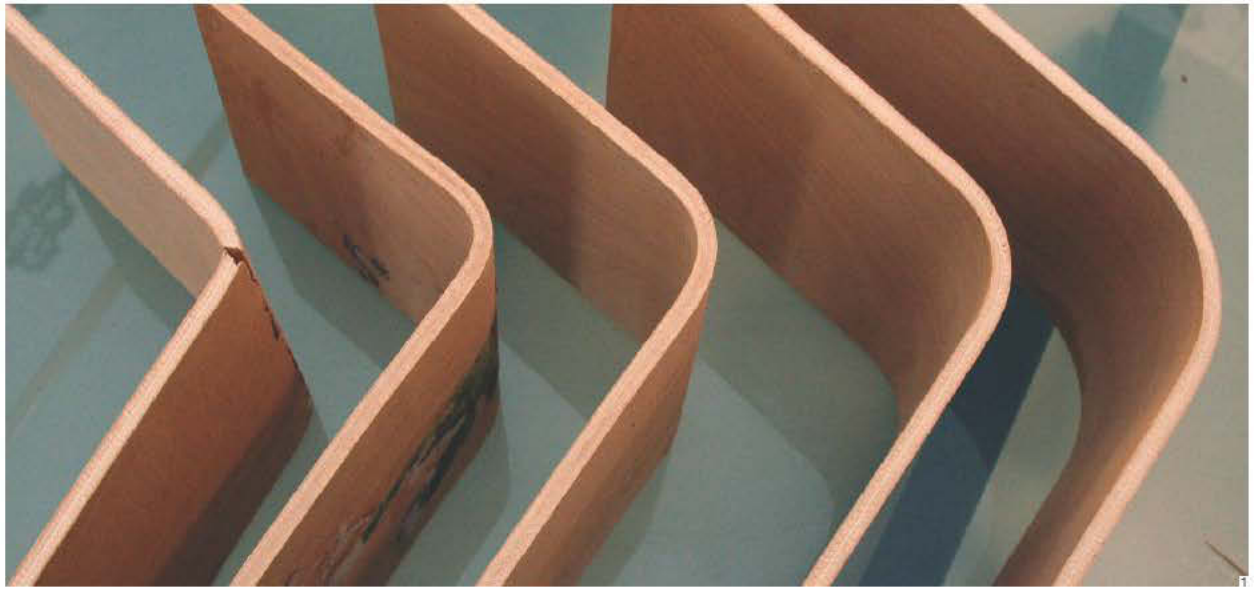
The Fuma and beech can go all the way down to a minimum radius in-between 1,5cm and 1cm.

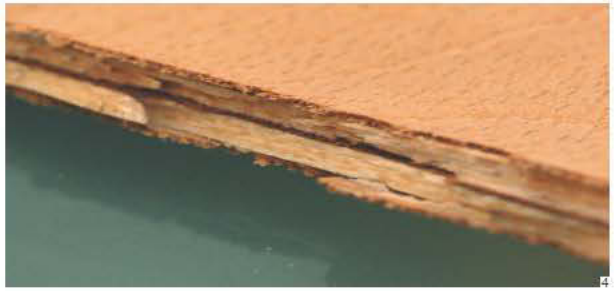
As I did the 1cm test I could hear aloud snapping noise from the accountable which where the Fuma cracking. The reason behind this might not be that Fuma is not flexible enough.

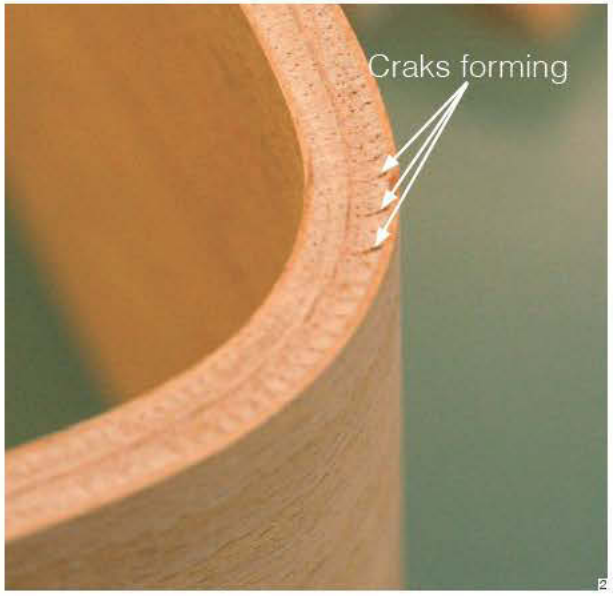
But rather that it is too thick and there for cant accommodate such a small radius. If I had thinner pieces of Fuma or single sheets of Fuma veneer I believe I could get it to smaller minimum radius.

I believe this is the case since I can see cracks forming on the 1,5cm test I did (image 2)

You can also se on the to close ups of the breaking edge that the Fuma is splintering further in to the wood. Compared to the thin outer Beech veneer, which has clean break all along the edge (image 3-4).







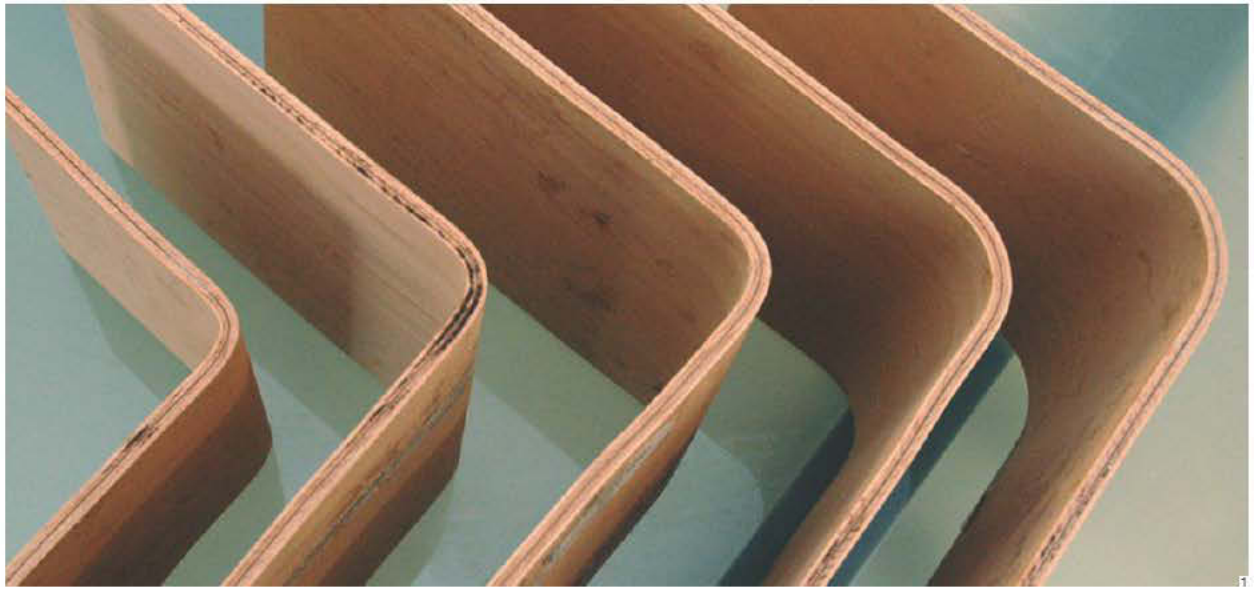
1,2,3,4 Fuma tests: Photo taken by the author, 2012

Beech tests

To step up my testes I started it all over again with beech as my core and outer veneer and mahogany as my centre veneer (image 3). The mahogany where choosen as a centre veneer for its dark cooler which would clearly indicate to me where the centre of my laminate where after I had shaped and trimmed it. The core beech veneer where 1,6mm thick and I placed it in the laminate with its grains going across the centre and outer veneer's grain direction from maximum flexibility.

The Beech/Mahogany laminate bent easier than the Fuma/Beech laminate. The might be because the total thickness of the laminate where only half of the Fuma and the veneers in the Beech/Mahogany could move more independent of each other in the pressing process. Image 1 shows the Beech/Mahogany laminate has a minimal radius slightly smaller than 1cm. I can see the core Beech veneer is almost cracking (image 2).I would not recommend bending beech in radius smaller than 1.2cm to be sure of the fact that it will not crack.

To conclude the test I can say that Beech veneer is a great material to work with and that I have acquired a degree of experience in the process of how to apply glue and stack the veneer sin the laminate for the most successful result comparing to my own skills with laminating wood veneer.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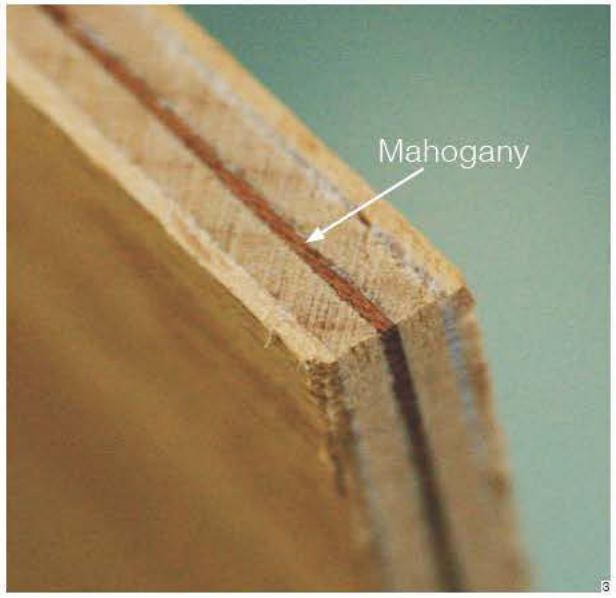

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1,2,3,4 Beech tests: Photo taken by the author, 2012

2.1 Compact living

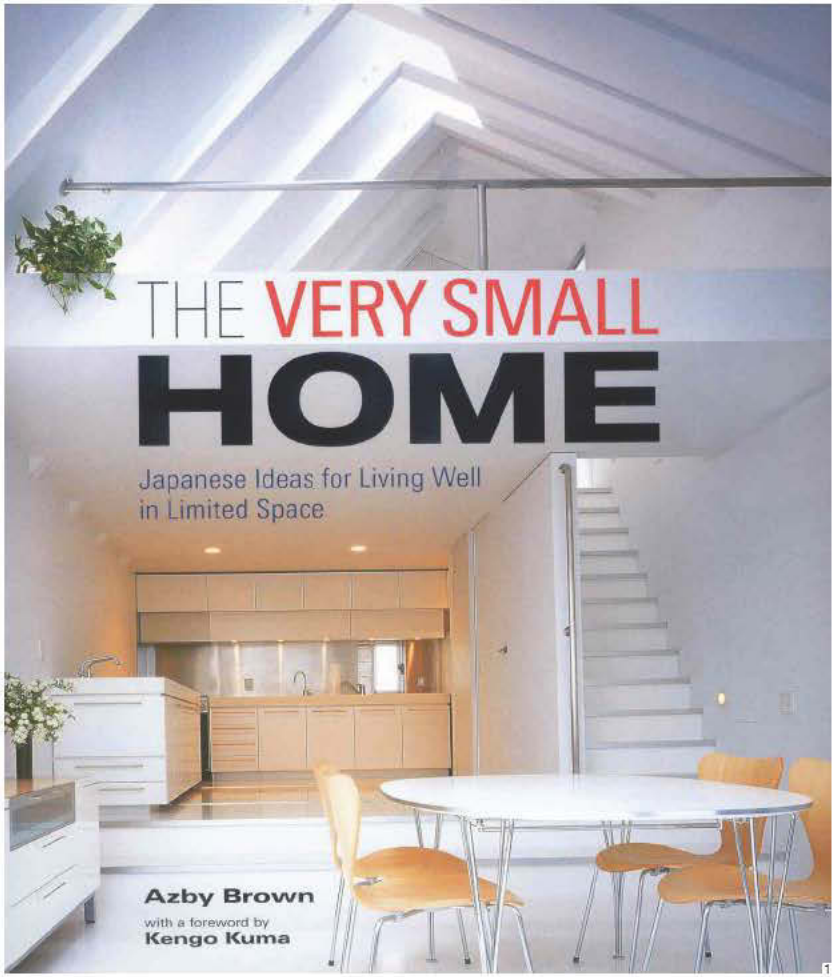
What is compact living? I must admit that I went into this project not entirely knowing what Compact Living is. I believed that compact living was: “To be living in a smaller space than what was commonly accepted as a normal living space over a longer period of time.” However this statement is not entirely correct as I where to find out.

“Compact living” means that you are getting more out of small places through innovative solutions and creative ways of organising your living space.
This means that it is possible to live in a very small space, but not be living compact.

As soon as one starts to take advantage of the entire room to create more space it becomes compact living.

The book: The very small home (bilde av boken) is a book that describes very small Japanese homes design by architects.

To showcase some of the solutions that makes a “compact living” home. I have picked one of the 18 homes on display in this book.



1. The Very Small Home, Azby Brown, Kondansha International, Tokyo, 2005

The house in Naka-Ikegami

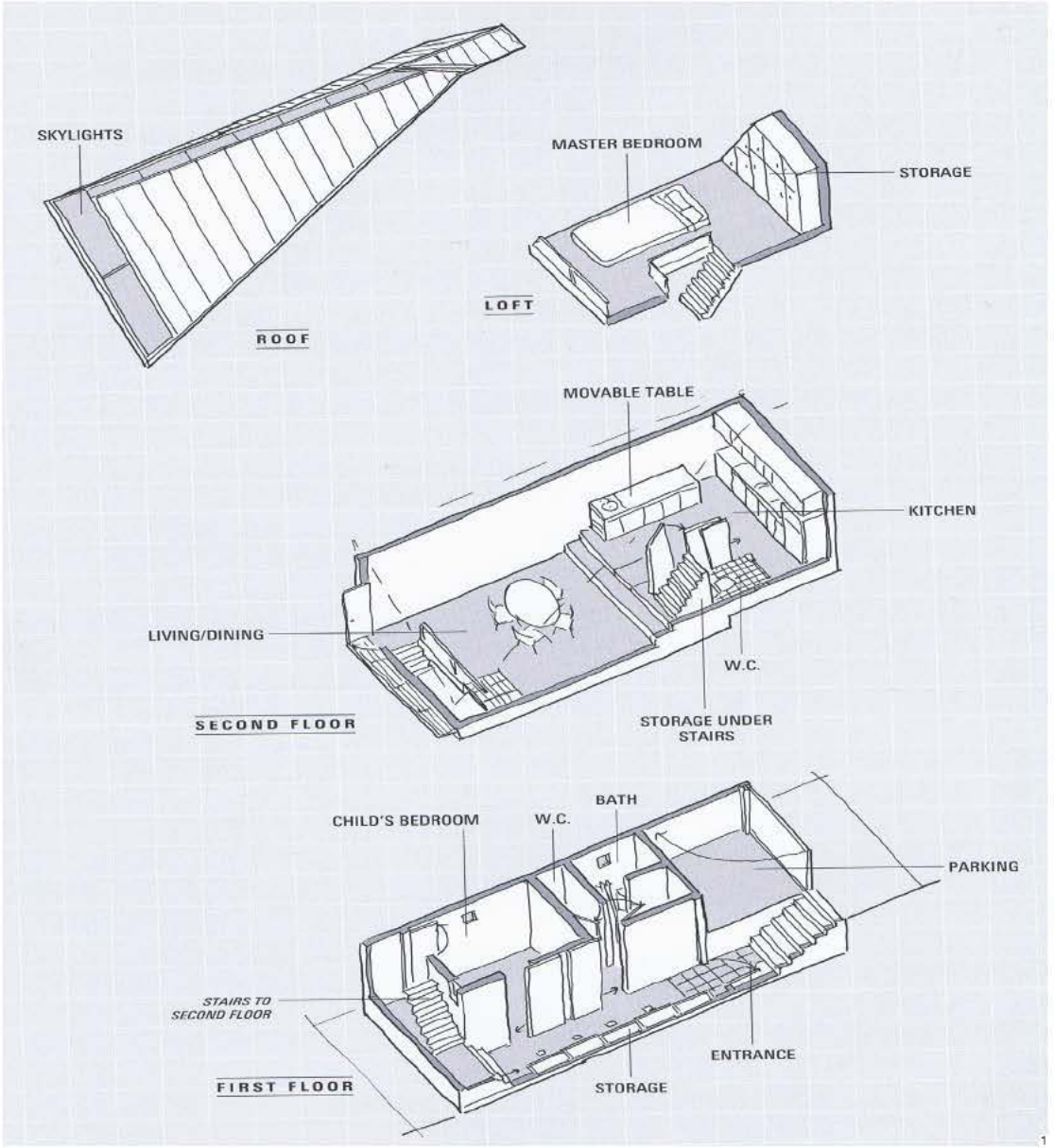
Design by Tomoyuki Utsumi at Milligram Studio.
The total living space in this house is 89.55 m^2
While its footprint is only 34.72 m^2

As one can see from these drawings (image 1) the architect has tried to create as much open living area as possible while ensuring that all the essentials of a house for a small family is still accommodate for.

The final key to this successful house is the exploiting of unconventional areas for storage. Which can be seen in the pictures on the next page.

The buildtin storage in the kitchen floor. (image 3)
The extra pullout Kitchen worksurface. (image 4)

89m^2 is quite big actually and there is no surprise that one can really fit in everything on wants if you are open to creative solutions and can build the house from the ground up. However there are some really extreme examples of compact living out there.



1. Floorplanes: The Very Small Home, Azby Brown, Kondansha International, Tokyo, 2005, page 36

1,2,3,4 Interior piotures:The Very Small Home, Azby Brown, Kondansha International, Tokyo, 2005, page 34-35

The cube project

This project is the initiative of Dr Mike Page at the university of Hertfordshire. He has constructed a Cube of 3x3x3m (image 1) where one person can live comfortably in a modern existence with virtually no impact on the environment. The house includes two modulare custome made chairs (image 2) as well as a full kitchen (image 3) and bathroom. Thers also several clever storage soloutions and of course a bed room.

I have included Dr Pages demonstration video on the DVD that can be found in the back of this report. It gives a indepth tour of the Cube.

This project where done to show that it is possible to live in 3x3x3m cube and that in the future we should look to the cube project for inspiration when we construct new residences.

However this is Compact living taken to the extreme. Although it is possible to live in the Cube I doubt that many people would feel that it is the most ideal living situation for them.

1,2,3 Cube images http://visuall.net/2011/09/04/compact-living-the-oube-project, 09/05/2012

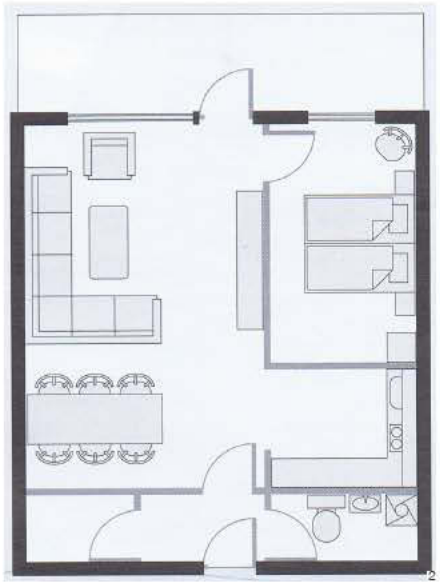
2.2 Compact living, A necessity?

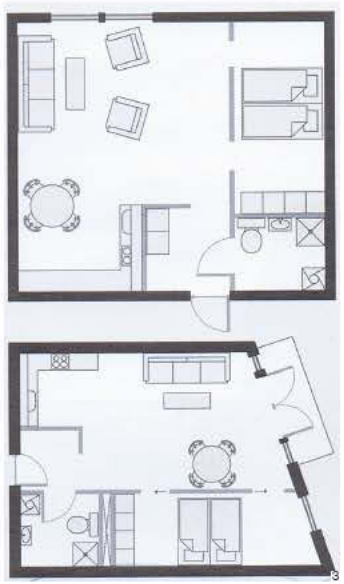
So if we don't have the ability to construct a compact living home from the ground up how can we make our non-compact living areas into compact living? More importantly do we have to live Compact?

The article "Trangt, Mørkt og Dårlig" by Daniel G.R.Butenschøn phublished 9 of desember 2011 in the weekly Magazine D2 (image 1)

This articel shines a light on this exact dilemma. The main theme of the article is the alarmingly poor quality in newly built apartment complex in Norwegian cities. Image 2 illustrates what was the worst apartments to build by the Husbankens standards in 1985. It is a 57 m^2 "poor apartment for 2 persons it has both a separate kitchen and a hallway, but is tight and has inflexible solutions. It is however a "Scoop" by today's standards 27 years later. Image 3 Shows the standards on newly buildt apartments in 2011

Apparently we build smaller and smaller residences our cities. The main driving power behind this trend is the shortage of apartments and houses in our biggest cities.





1. Forside D2, Terje Tønnes / Sigurd Fandango phublished 9 of desember, 2011
2. Dårlige tider, Terje Tønnes, D2 Magazine, phublished 9 of desember, 2011, page 13
2. Leve Laila, Terje Tønnes, D2 Magazine, phublished 9 of desember, 2011, page 13

Further out in the article we find this quote from residence researcher Bendik Manum, form NTNU:

“ We are building apartments that are smaller, tighter, and darker than we have ever done before in modern Norwegian construction history.”

According to statistics in Oslo more than half of then newly construct residents in Oslo is smaller than the earlier standard of 55m² from the Husbanken in 1985. Many of these are smaller than 30m²

“Small apartments that are both good and flexible do exist, but rarely in new, the first thing to suffer when the residence become smaller, are its floor plan” Bendik Manum.

From looking at the floor plans of new apartments we can see that the first thing to disappear is the hallway, then the kitchen and living room is combined into an so called modern open solution as we can see from the floor plans on the last page (image 3).

Finally the article has a nice collection of facts for Norwegian apartments from 1930 until today. This works is from Bendik Mannum PhD where he went through tree and half generations of floor plan drawings for Norwegian apartments after the Second World War.

Norwegian apartments from 1930 to present

Type A: From ca 1930 to 1955. Residents with multiple possible living areas due to large rooms, Good natural lighting conditions and each room can be accessed through hallways.

Type B: 1960 to 1980. Bigger apartments with more and rooms that are more specialised. Each room in naturally placed according to its neighbouring rooms uses

Type C: from 1980. Less rooms simpler layouts. Kitchen and living room merges. The bedroom becomes smaller and is only intend for sleeping while t he living-room/kitchen becomes the main living area.

Type C+: after 2000. Both the residence and its rooms shrinks. Commonly there is only a single bedroom if any. There are hardly any separate kitchens, all the windows are facing in one direction with no regarded for the suns placement.

[1]

To me this article clearly illustrates the fact that we now are going to live in smaller and smaller residents an as long as we live in a city. Unless we are of a privileged few that can afford the few big apartments. Clearly there is a need for compact living.

Since most of these new apartments are not built with compact living in mind like the Japanese house or the more extreme Cube project. There is one solution left to the residents of these apartments. They have to use their furniture or interior in creative way so that they can exploit all of the space that they have in their residents.

1. Norske leiligheter fra 1930 til i dag, Bendik Manum, D2 Magazine, phublished 9 of desember, 2011, page 20

2.3 Compact living Furniture

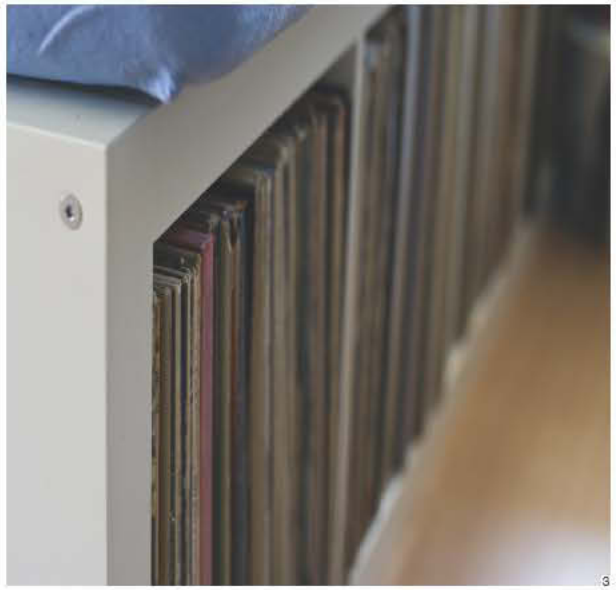
The easiest and many times only option than people have to change their residence is their configuration of the interior or the furniture. One can say that almost all furniture is a way of compact living as long as it can do more than one thing. A desk can be used as a work surface, dining area or recreational area. The desk can have storage possibilities in addition to its main purpose of being used as a works surface. To use a desk in this way is not very controversial.

When people use furniture in a way they where not design for it starts to become interesting. There is a whole website dedicated to “IKEA hacks” Where the users upload their “hacks”.

From the IKEA hack site:

“Essentially, an IKEA hack is a modification/repurposing of an IKEA product. Why I chose to call it a hack? In it’s own little way, it breaks into the IKEA code of furniture assembly and repurposes, challenges and creates with surprising results.”[4]

A great example of this type of hacking a furniture can be seen in this example of a bed made out of ”expedit” self units. They create storage area under the bed in a stylish, and personalised way.
(image 1-3)



1.http://4.bp.blogspot.com/-4HdMGK5O-Nk/T59xYoBYb_I/AAAAAAAAfrw/orNmTeM_ZUY/s1600/ExpeditBed4.jpg 2012
2. http://4.bp.blogspot.com/-Njqw4pThnPg/T59xX3bnQ3I/AAAAAAAAfrM/OvWdWue2GLo/s1600/ExpeditBed1.jpg 2012
3. http://2.bp.blogspot.com/-HyeD1K4O2to/T59xYO5cPnI/AAAAAAAAfrY/52t1NOwRJtU/s1600/ExpeditBed2.jpg 2012
4. http://www.ikeahackers.net/p/quick-start-guide-to-ikea-hackers.html 2012

Furniture designer have taken these design features to heart and there exists several hundred “compact living furniture solutions”

Just through a quick search online I find several hundred interesting multipurpose or modular furniture, furniture that transform into a different type of furniture to save space and finally the magic box furniture which can be taken apart and transformed into an object which is easy to store or move and transport. I will go through each of these categories with a few examples of the best types of furniture that I found in each category.

2.4 Modular and multi purpose furniture

Mathroska

This is one of the most though modular and multi purpose furniture system that you can buy, without it being incorporated into the construction of your residence. Mathroska combines a works or study area with a sleeping area, several storage solutions, Dining area and a relaxing or recreational area. The studies area cannot be transformed while the Sleeping /bed/ Dinning area is very flexible. As shown in the images 1-4 and image 5-8 on the next page

I see only a few draw backs with this system. Mainly it uses up a lot of floor space, The user have to commit to the system as it is not really optional to only purchase a part of the system.

It is however a very good solution for the users that can take the step and fully commit to all of it solutions. It needs to have the rest of the room shaped and adapted to fit around it.

1,2,3,4,5,6,7,8, http://matroshkafurniture.com/home/galleri_bilder.html 2012

More

This is modular shelving system where the units have to be screwed together. But the modules offer up almost infinite number of different configurations of build a storage system out of the modular parts. (image 2-3) The modules can also be used to build other basic shapes with can functions as stools or tables at the same time as being used for storage.

This is genius system. However it is quit material intensive as each of the modules are made up of 4 to 6 CnC cut squares of plywood with spacers in between the squares where it does not connect to another module. (image 1)

The More system is very sturdy because of the screws that goes through the modules which links modules and keeps the individual modules together how ever there are many screws and it seams like its quit labour intensive to change the configuration of the system because of all the screws that has to be undone.

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3

1. Singel module: http-_www.caporasodesign.it_images_Photo_More_image-4, 2012
2. Example of use: http-_www.caporasodesign.it_images_Photo_More_image-14, 2012
3. Z shape: http-_www.caporasodesign.it_images_Photo_More_image-002

2.5 Transformer furniture

Doc sofa / bunk bed

This is a sofa that becomes a bunk bed just by pulling on a few parts and without adding any extra parts to the furniture. It is an interesting concept and very advantageous in small apartment where you can have a bed a t night and sofa in the daytime. (image 1-3)

However even though it easy to change over would you still want to it everyday. I believe that people will leave this in one of it two configurations and only change it when it's absolutely necessary. There is nothing bad about that, but does it not defeat the purpose of the transformer furniture.

1. http://www.bonbon.co.uk/olei/phbin/doo/doo_01_press.jpg
2. http://www.bonbon.co.uk/olei/phbin/doo/doo_02_press.jpg
2. http://www.bonbon.co.uk/olei/phbin/doo/doo_03_press.jpg

Changeable

This is chair that becomes a coffee table (image 1-3). Its an interesting concept and very well executed.

However as with the sofa bunk bed are you really going to change it daily? I believe that with this product that is not necessary, you might need the coffee table when you have guests coming over or the opposite you might need an extra chair.

1

2

3

1,2,3 http://www.shape-shaped.com/shape-shaped%20changeable.html, 2012

2.6 Magic box furniture system

Casulo

Casulo is a True “magic box” furniture system. It is aimed at creating a set of furniture which is easy to unpack and pack and then transport as you move from short term residences or for students abroad in short term accommodations. It is a brilliant system that has managed to fit every type of Furniture into a small box shown on the pictures above.

There is also a video of the unpacking process on the DVD in the back of this report. A few of the steps involved can be seen here (image 1-4)

Casulo is very similar to Mathroska in the way that it catters for all of the need for a single person in nice little package.

However sacrifeces are made in the name of mobility and it is only the bare essentials that are present in Casulo System. There is nothing wrong with that when one considers its main use as Temporary short-term furniture set.


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3


4

1,2,3,4. http://www.mein-casulo.de/img/fotos, 2012

2.7 Conclusion of compact living research

These are just some examples of what already exists in the “compact living” furniture world. I do believe that they all have theier uses and can be abssulotly brilliant for the users who choose to purchase and use them.

However I find these concepts to either be to over complicated where the system tries to solve all of the problems within the compact living setting. On the other hand some systems have identified a problem and tries to solve just that one with now regarded for other problems or issues that may arise in a “very small home”.

Through my studies of these furniture’s and furniture systems and the current construction trends in Norway’s big cities identified and questioned in the D2 article by Daniel G. R. Butenschøn.

I have identified a few key features for what I believe is essential in a successful “compact living” furniture or furniture system. These are indefied in the table 1.

We are moving into an age where there will only be more people wanting to live in our cities which will continue to drive the prices up and size of the apartment s down.

Essential compact living furniture features

Modular. The system or furniture has to be modular so it can be customised by the user to fit the users need.

Multifunctional. The system or furniture must be able to be used in many different ways. A key feature here is storage pluss something else like seating, work surface, Dinning, recreational.

Mobile. The system or furniture has to be easy to take apart and move to a new location where it must be able to be adapted to its new environment. The user needs and requirements of the furniture might change in the new location. The system must be able to cater for these changes

1

3.1 Design process

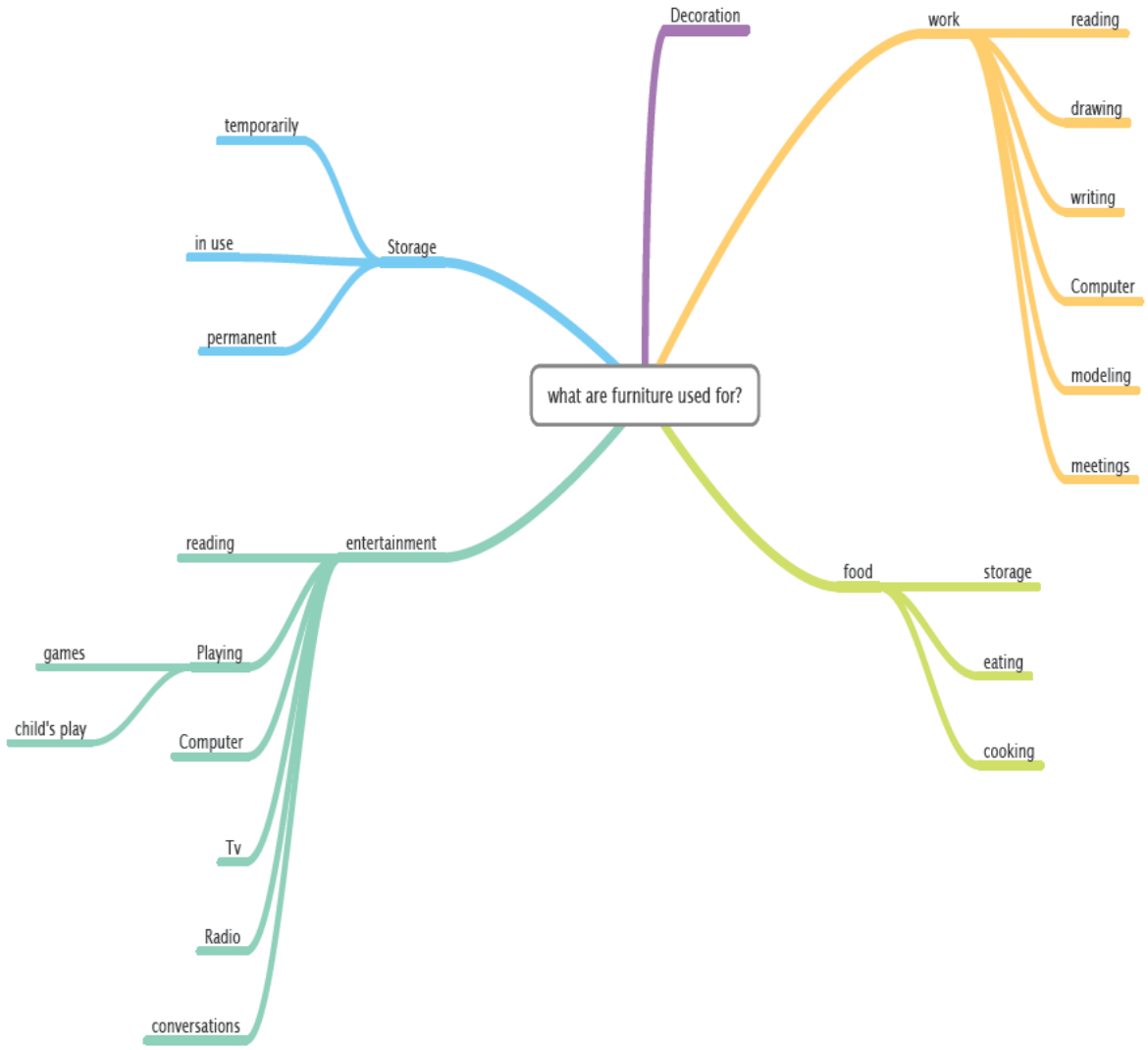
Initial idea

With the three compact living features from my research in mind I went about a brainstorming session with my guidance tutor. (Image 1)

Going through the results of the brain storm it was clear the in order to create a product that could cater for all of the needs a user might have to compact living furniture system it had to be simple.

The system should let user be inspired to create solutions that are custom fitted his or hers personal needs. Finally the system should enable and encourage this type of behaviour and not restrict it

Almost immediately an idea of a modular storage system occurred.



1

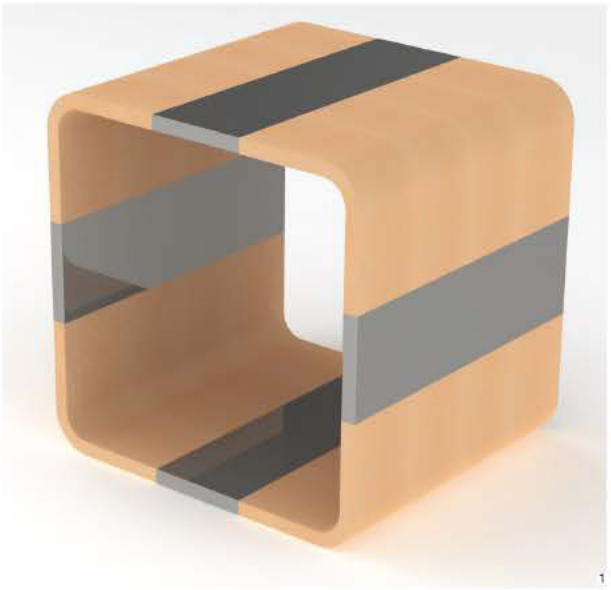
This system is using three different types of parts as shown in . The simplicity of this system comes from its simple parts which can be used to create large range of combinations. (image 3)

The users only need to purchase the parts that they need for their use. A box can be made out of four corners or a combination of boxes can be made (image 1). The partes would be held together with combination of magnets and snugg fitting metal bands (Image 2).

These simple boxes can function as Work surfaces, Storage or sitting. By combining multiple boxes or parts the system can become multi functional and serve as sitting or work surface as well as being storage. (image 3)

This where to be my Initial concept.

There where still problems to be solved, in the actual design and construction of the product, but to test my idea and to get feedback on additional features such a system would need. I decide I needed to do some form of testing on people to see if my compact living research results and concept where valid.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3.2 The experiment

To find the right way of testing my concept I used "IDEO" Method cards. These cards where developed by the design studio IDEO. The cards describe a method that they use or have used in one of their studios. It is an excellent tool to find new methods of gathering design information or to explore new approaches to a problem.

As a basis for my user experiment I chose these cards:

1

Body Storming: This method was as a way for me to get my test subject to try their hand at using my concept. It should help me to identify new features that are needed or problems with concept

Scenarios: This method was chosen to ensure that the test subject stayed true to the essence of the experiment and did not deviant. It also helps to put the subject in the shoes of the imaged user and makes them consider them self as a potential user there by validating the experiment.

Fly on the Wall: this method was chosen as a means of observing the experiment with out interfering with the test subject perceived situation due to the scenario being in effect. It helps to reinforce good results from each test subject.

Time laps Video: This method was chosen as a way of recording the experiment. Time lapse was chosen over normal video recording to the fact that I could you my digital SLR Camera. Which results in better quality of the overall recording and less data space while recording.

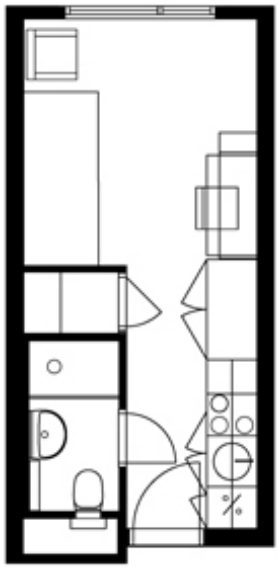
The reason for the experiment is to test how people think and act as they furnish a small residents when they have almost unlimited modules available to them. These modules can represent everything from tables and desks to shelves and seating.

1. IDEO method cards, www.ideo.com, unknow phublising info (there are no publishing info on the carddeck box)

To find an average floor plan of a small apartment in Oslo. I looked on SIO, the student housing organisation in Oslo's web site and made an average of the floorplans they had of the different Student apartments in Oslo. (image 1-3)

This average floor plan became a 19m^2 apartment with open solution where the kitchen, bedroom and living room where combined while it had a small bathroom. (image 4)

This experiment had to be conducted in 1:1 to get accurate data from the test subjects. So I had to build this "apartment" in real scale. To achieve this I used already existing exhibition boards from the works shop. Luckily these where quite big as you can see from the images on the next page, there where enough of them for me to make the complete apartment with out making more boards



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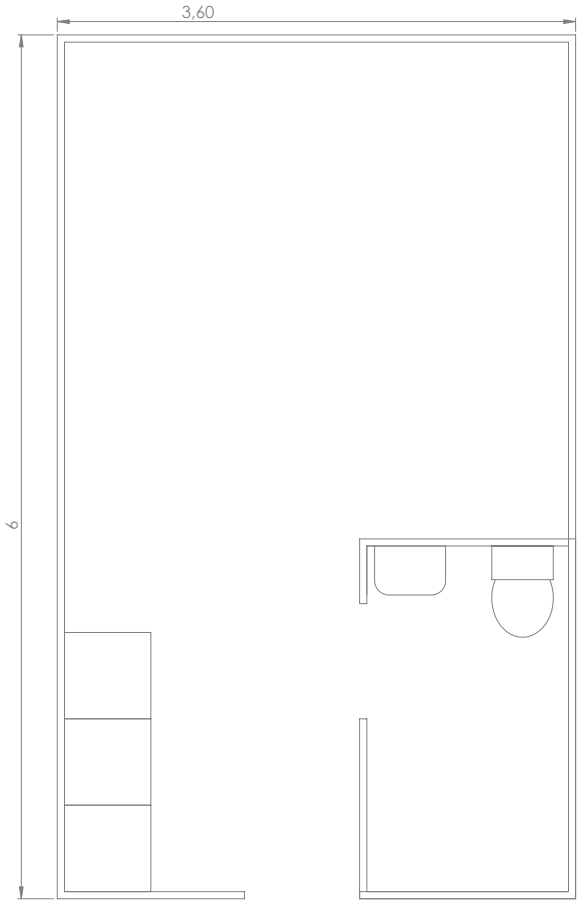

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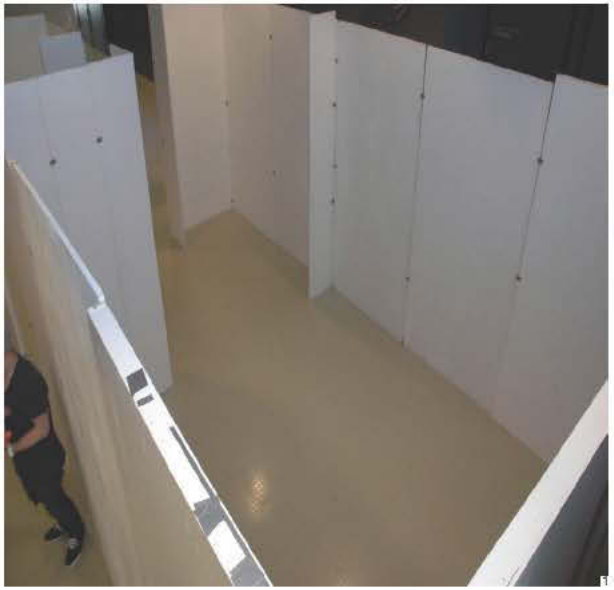
1. Møblert 1-roms leilighet for single, Bjølsen Studentby, https://www.sio.no/files/bolig/plantegninger/Bjolsen/BJO1-roms01S.jpg
2. Umøblert 1-roms loftsleilighet for single, Iladalen Studenthus, https://www.sio.no/files/bolig/bilder/Iladalen/Hybelleilighet_skisse_S.jpg
3. Umøblert 1-roms leilighet m/sovealkove, Pilestredet Park Studenthus, https://www.sio.no/files/bolig/plantegninger/Pilestredet%20Park/PIP1-romsA01S.jpg




GRILLMAT

The “modules” would be made out of cardboard. To make it easier to understand the experiment and for me to construct the modules I made complete boxes that where open in one end.

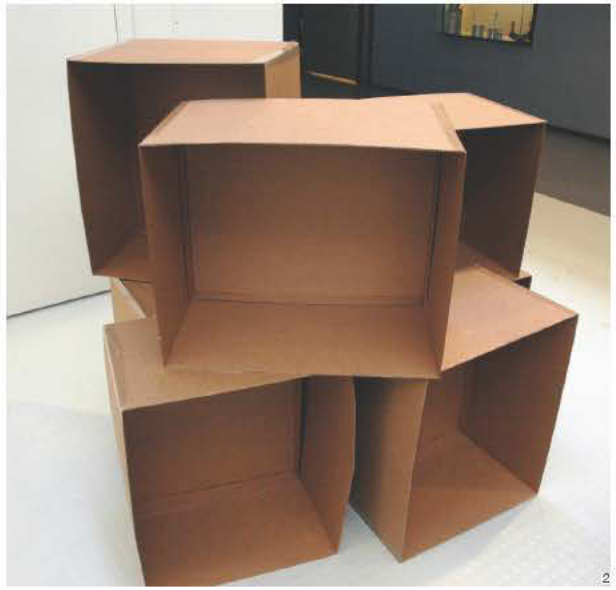
So that the experiment still would be valid I made almost every combination I could think of in sizes from my original concept in these boxes some can bee seen on images 1-3. I also ensured that there where more than enough of each type of box.

To give the test subject a degree of realism I created a large amount of closed boxes and smaller boxes that could represent personal items or other furniture that where not modules (image 4).

Appliance and items that are already installed in an apartment where represented with cardboard boxes taking up the approximate volume, these where things like: Toilet, Sink, and Cooker etc. (image 5-6 on last page).

A window where represented with a black tape on the end wall of the apartment. (image 6 on last page). finally the test subjects where given small acrylic tags and a whiteboard marker which they could use to tag their Furniture if they wanted to say something specific about it or its use.


1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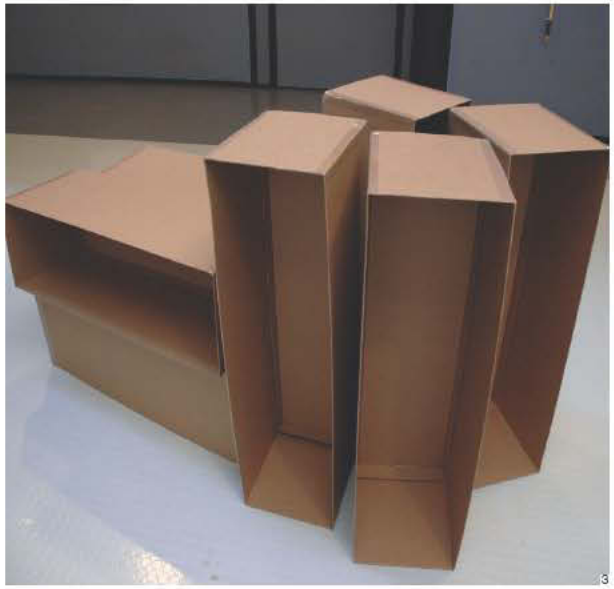
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The scenario

Each test Subject got the same scenario described to the and where ask to act on it accordingly. The scenario where:

“This is your new student apartment. You will be living here for a period of two or more years, the items that you se already in the apartment cannot be moved. You can use these “module” boxes to represent furniture as well as these other boxes to represent personal items or other furniture”

Then I would withdraw and let the test subject do the experiment until they asked for help or said that they had completed the task to the best of their abilities.

The initial impressions and observations of test subjects.

The experiment where completed by nine test subject all students. I have made video of theier the time lapse I recorded of them while they did the exeriment it can be found on the DVD in the back of this report. I do more in-depth observations of how each test subject preformed in the experiment.

Every test subject did the experiment differently, but there where certain things that some did similarly. I have categorised and commented their furniture creations in the following pages.

TV stand

Six out of nine made TV stands, out those six two made big stands incorporating a lot of storage into the stand and making it major part of their apartment. (image 1-2)

The other 4 made smaller TV stands where the stand where more proportionate to the actual TV. Out of the six, four had TV stands made out of open modules this included one off the big Stands.)image 3-5)

The reaming two made closed TV stands where this included on of the big stands and possible the smallest stand. (image 1 and 5)

Sleeping sofa

Only two out of nine made sleeping sofas or a sofa bed. They expressed that they wanted something that they could use as a bed or as a sofa.

Extra kitchen counter or work surface

Five out of nine made an extra kitchen counter or work surface, in the kitchen area.

Two of these solutions incorporated more storage space underneath the work surface in both open and closed modules. (images 2 and 4)

The reaming three where bar counter solutions with out storage under the work surface. (images 1 and 3)

Storage in the entrance

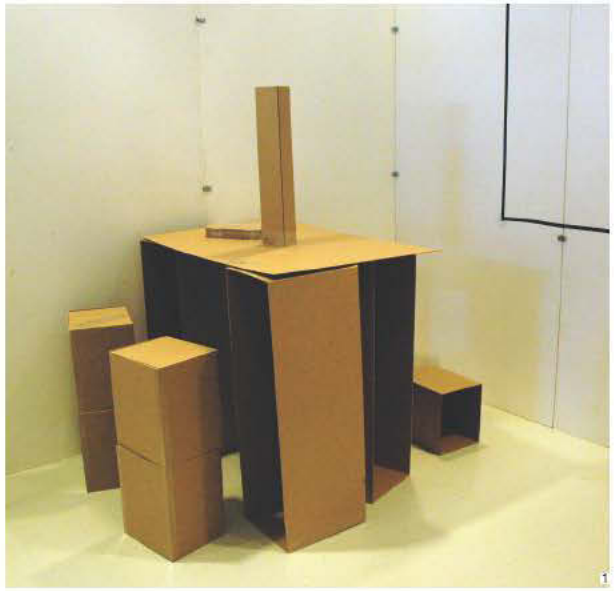
Five of the test subjects made storage solutions in the entrance of their apartment. (image 1-4)

Stating that it would be for outdoor clothes and/or shoes. There was an even mix of open and closed modules used between the subjects

Table storage

Four out of nine made freestanding tables with modules for storage. All of this storage solutions where made with open modules.

Out of the four, two where coffee tables (image 3-4) while the reaming can be classified as dinning tables. (image 1-2)



Making rooms within rooms

Two of the test subjects tried to use furniture constructed out of modules to separate and create rooms within the apartment. (image 1-2)

Closed modules

Only one out of nine built the solutions with only closed modules.

The tidiness and neatness where very important for this test subject. She also used the least amount of time and modules overall. (image 1)

Open modules

Four out of nine only built solutions with open modules. (image 1-4)

These test subjects used a lot of modules and many of them refurnished several times. Before they where satisfied with the outcome.

Some of the best storage solutions in the authors opinion where created by these four test subjects.

Open and closed modules

The reaming four test subjects used a mix of open and closed modules to create their furniture solutions. The author believes that these had the most normal or conservative solutions when it came to furnish the apartment. (image 1-2)

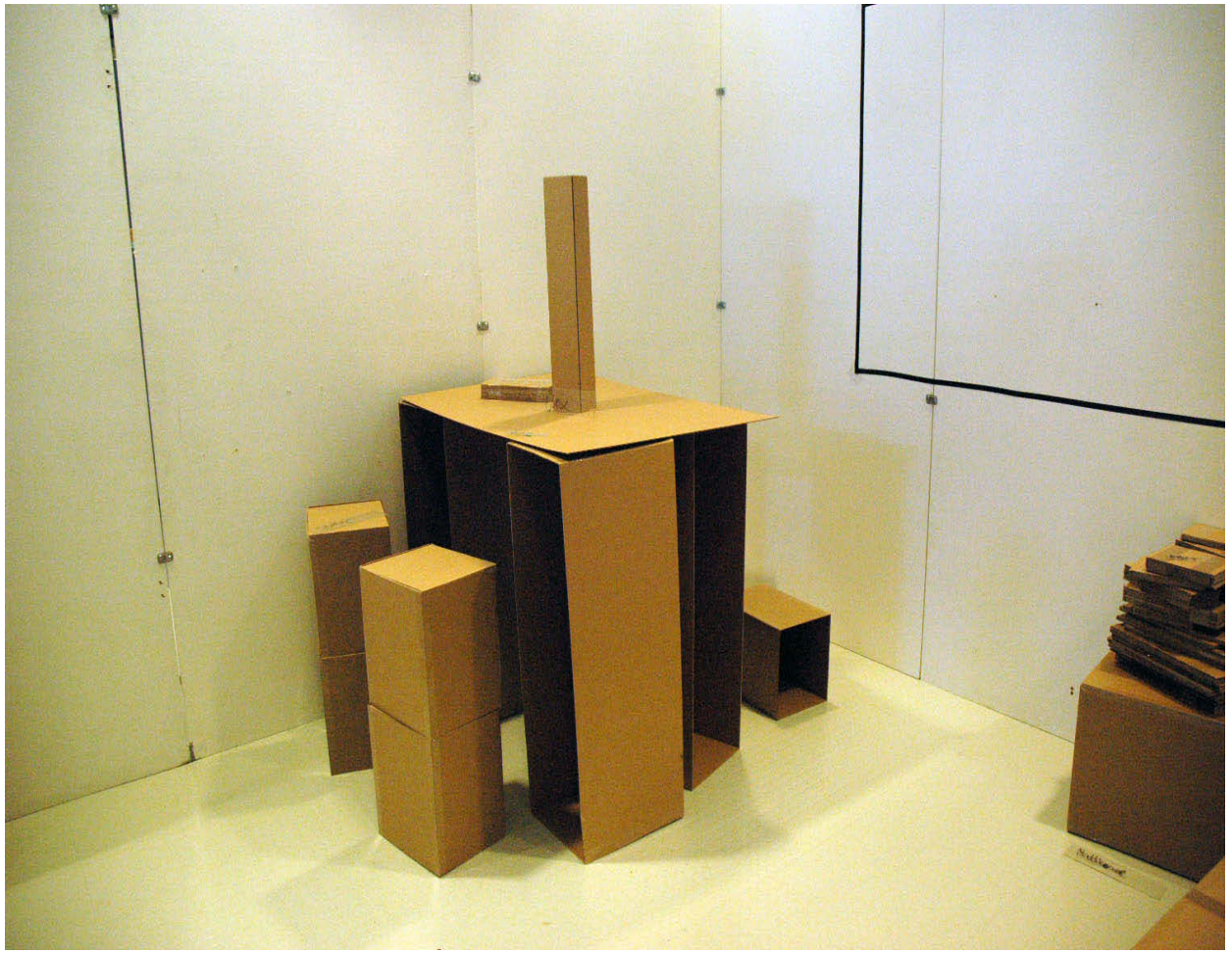
3.3 Interesting solutions

Three of the test subjects create very Interesting solutions. I selected these because of their uniqueness compared to the other test subject's creations.
I have studied these closer and will give short descriptions of each system

The tall table

The test subject has used open modules to create a tall standing table. The modules make up the four legs of the table and sheet of cardboard functions as the tabletop.

It is interesting because it shows how she has thought outside of the box when it comes to creating her storage and table solution.



A desk in a shelf

This test subject has combined his workstation and storage unit into one entity. He was the only one who did this. (image 1-2)

I have seen these types of solutions before. But it is interesting because he has used only open modules to create his solution.

After building it he expressed that he wanted to cover the entire wall up to the ceiling, but sadly he had used up all of the cardboard modules that I had made.

Funky Shelf's

These shelving units where made bye one of the test subjects. The small shelving unit has open modules pointing out to the sides, which you can't see from the image. (image 2)

I found these solutions interesting because the test subject has not restricted himself to conventional shapes when he has devised his storage solutions.

He has been inspired and created something that suits him and that is interesting to look at. It is exactly this type of behaviour that I want to encourage with my product.

3.4 Conclusion of the experiment and implications on my design

The experiment showed me that every person changes and adapts their living area through their furniture to fit their own needs and requirements. Although this might be an obvious result. What is more interesting is that individuals that is given that same apartment to furnish with the same amount and “furniture” in this case cardboard boxes. Comes up with unique solutions believe that not one of my nine test subject created a furniture that was identical to one that another test subject had created.

To see how most of the test subject created a solution with the modules only to take it apart and rebuild it differently to better suit them where very interesting. This enhances my belief in having a modular system, which is easily changed and expanded with out the need for complicated tools.

Further more all of the test subject where very happy with the experiment and thought that it was more fun and interesting exercise than they had believed it would be when they started it.

I believe that the result from the experiment validates my initial concept idea. However there are some features that I had not thought of which should be present and considered:

- A way of closing a module. Some sort of door system. This would cater for the test subjects who used both open and closed modules and the one who only used closed. However there where also several test subjects that did not want closed modules. The closing feature of a module has to be optional, and it might not be possible to create a modular enough solution to the problem.

- The system has to be made out of reasonable measurements. One test subjects suggested that I make each stage of a module dividable on 10cm so that it is easy for people to figure out how many parts they need to build their modules and how many modules they can fit in their residents

- Colour options and the ability to customise the modules, should be something that the users are encourage to do. One test subject suggested that I should have several colour and material options, but also have a untreated option that the user can paint or treat it them self’s to match their residents or requirements.

4.1 Prototyping and Tests

The final concept

These are my CAD models of the final Concept. As you can see I have taken most of the results my experiment into consideration when making the changes.

I could however not figure out how I could make a simple way of closing of the modules and still keeping it to a minimum amount of parts. There are already 21 different box combinations with the parts you see here (image 1). I feel that creating 21 lids or doors would not be in the spirit of the 7-part system that the concept is now.

I have however taken into account my two other results as you can see from the different colours and materials being displayed here image (2-5), as well as the measurements of the modules all of the possible box combinations are dividable by 10 centimetres. (image 6)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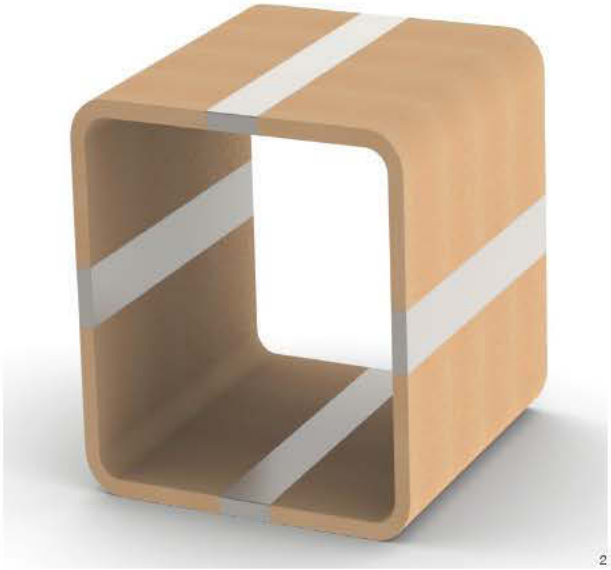
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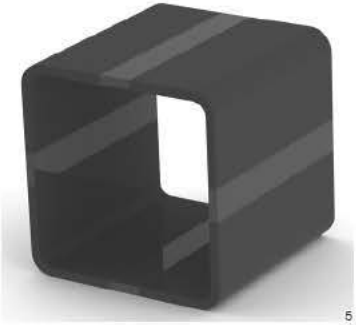
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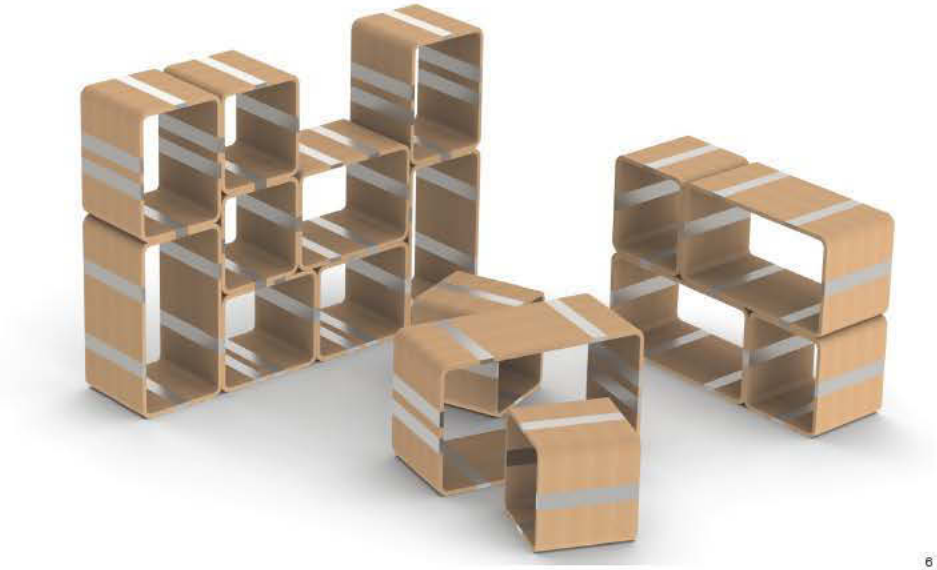

6

Joining the module parts

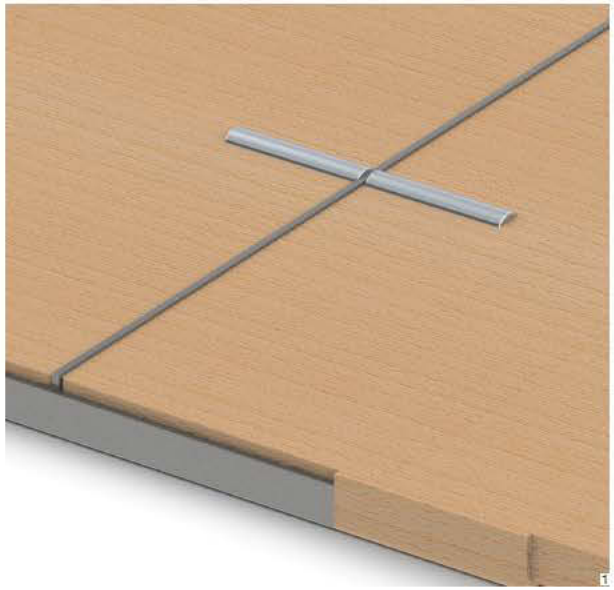
To test my concept I began the process of building a fully functional model. The first thing that I had to test where my “Metal-band and magnet joint.” The System uses a combination of magnets and tension between the wood and the metal band to join the parts together. The metal functions as a anchor for the magnets which makes it possible to join any parts togehter. The magnets them selfes are glued into the ends of the wood modules. (image 1)

After explaining my concept to one of the technicians and trying to create just one of the four pieces of metal that I would have to bend and weld in order to just try to make one part. (image 2-4)

The metal had to be as thine as possible to keep the parts light. Welding this four U-shaps together would require expert craftmannship. while there was always going to be a risk that the meatl would warp because of the heat.

I had to be able to produce as many as possible of these links at least between 30 and 50.

My biggest problem would be to get them to all be identical which is a challenge when you are not an industrial welding robot.I decided that it would be to difficult and take to long to manufacture.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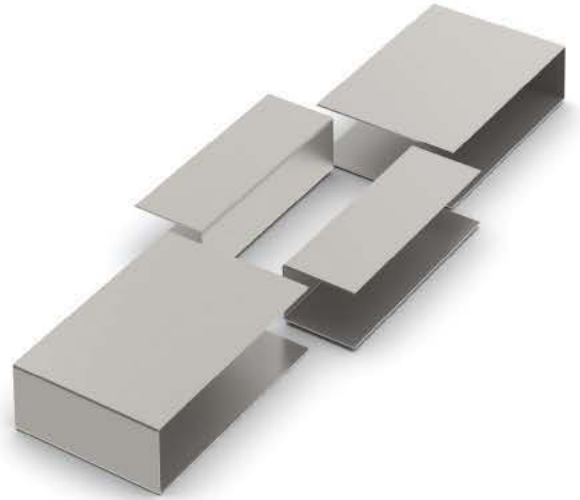
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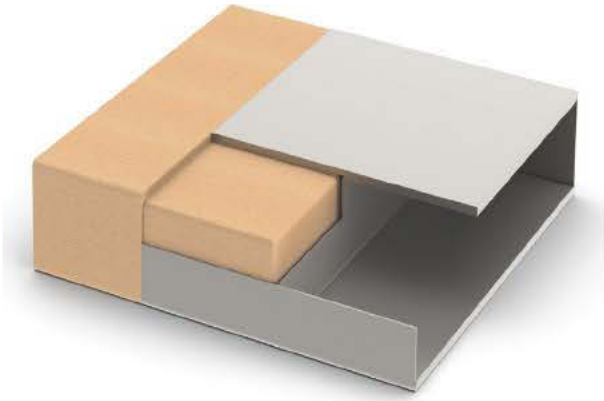
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This meant that I would have to come up with a new mechanise for joining my module parts together. It had to be simpler and easier than my original idea while retaining some degree of the esthetical features from the original idea.

I decide to try to just link the modules with Rare earth magnets as the link instead of using metal as the link and magnets in the module parts. This would ensure that any module could fit any other module. However I would lose my metal strip or band. Since i would have to fit some metal into the wood instead for the magnets to join themselfs too.

This test where done with small and weak magnets. (image 1-2) But it proves the concept I have found some longer and stronger magnets that might be better at joining the module parts. The weeak magnets loose their grip of the metal very easily.

The holes that the magnets have to fit in to have to be drilled on the exact same spots on every module or else they will not fit properly together and I will get crocked modules. (image 3-4)


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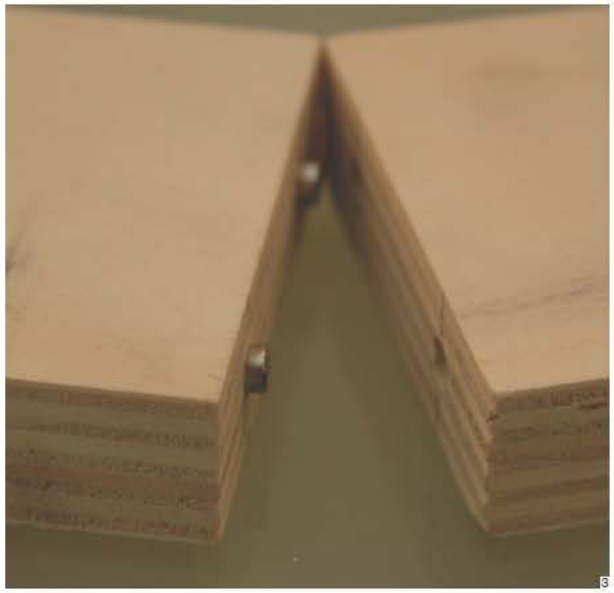
2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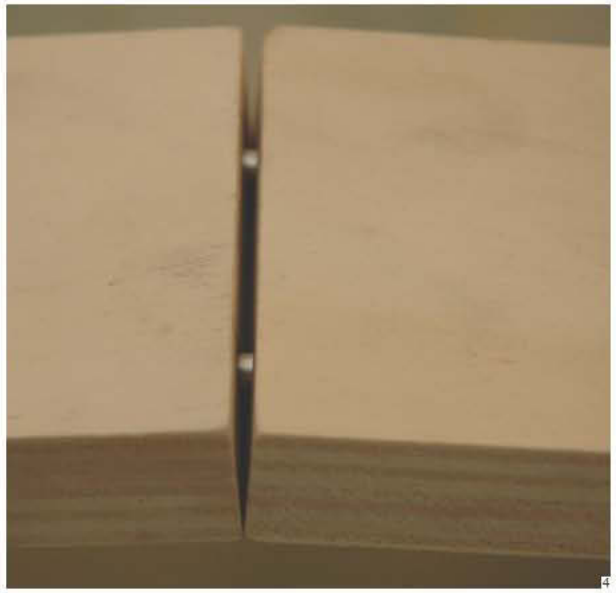
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Here I have tried the new magnets on a new test piece of plywood. This time I used a centre tool (image 1) to make sure that the holes for the magnets where drilled in the exact same location so that the two test parts would join seamlessly to each other with the aid of the magnets. (image 2-4)

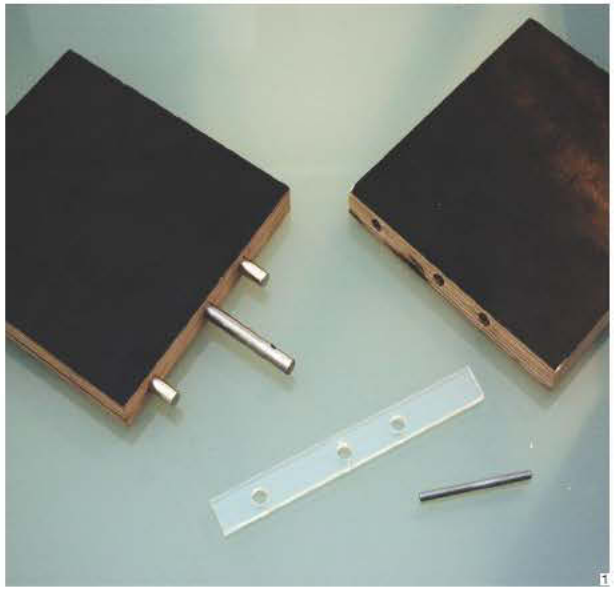
The test where successful

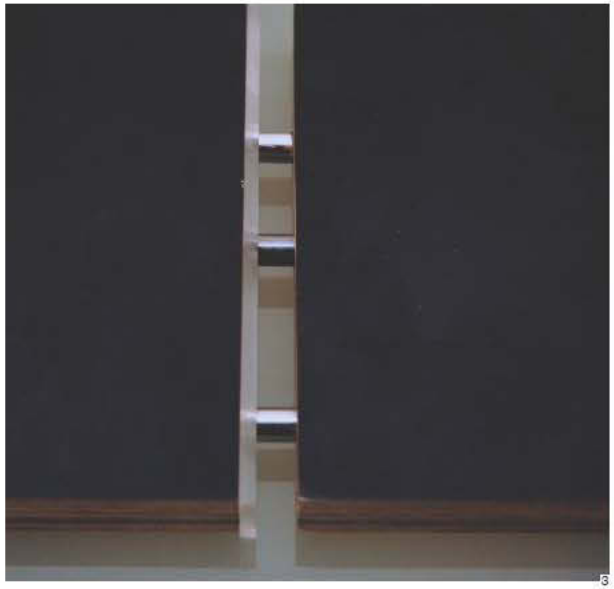
However after conducting some strength tests where I simply tried to break the piece apart I found the magnets are still not long enough to create enough stability with the parts. (image 5)

I drilled a third hole using the same tool and inserted a steel rod 5 cm into each of the parts. This made the joint more than strong enough. (image 1)

The last thing to sort out before I could start to build my modules where how to bring back the esthetical features of the metal band from my original concept.

I decide to use a piece of acrylic and sandwich it in-between the to parts to create a buffer between the module parts as in my original concept. (image 1-4)





4.2 The Prototype

Building the model

I started by creating three moulds for laminating my beech veneer (image 1).

I spent three days laminating twenty-one ninety degrees corners each with a inner radius of 2.5 cm I then proceeded to trim the edges while trying to make them as straight as possible.

This was very hard as both the spring back effect was working against me and the pieces did not fit properly on the workshops circular saw. I ended up with 16 parts which was an as straight as I could make them and the model is 4 cm narrower then the concept

I then cut out all of my flat module parts and drilled holes using the same tools as I used in my test.

However because of the small variations in the corner parts small gaps and certain parts did not fit properly together.

I decide that the only way I would get a model that would look anything like my concept I had to make four module-boxes with flat module-parts specially fitted and cut to each box.

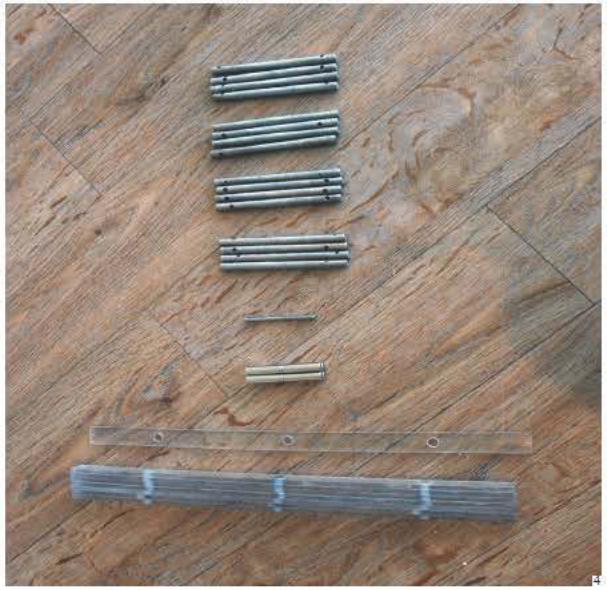
Because of this I cant interchange parts between my modules in the model, but I have four models that look like my concept and functions according to my concept individually.

The finished Prototype model

This is the finished model. The model is four modular boxes each compromised of four corner parts and at least two flat parts. (image1-2)

Each joint or link between module parts is comprised of a Sheet of polycarbonate a rare earth magnet and two 10 cm long steel rods. Image 4 shows all of thiss joint parts for one box.

Each of the prototype modules has a set of parts that belongs to it, reperesting the diffrent parts in my system. The Boxes can change their shape and size by replacing the straight parts for longer or shorter part. (Image 3)



To build a module you simply fit the parts togethere. (images 1-3)

Some times a small steel rod can aid the deconstruction and construicuion prosess by helping you to get a grip on the steel rods. (image 4-5)

I have created a Time laps video of the Construction process. It can be found on the DVD in the back of this report.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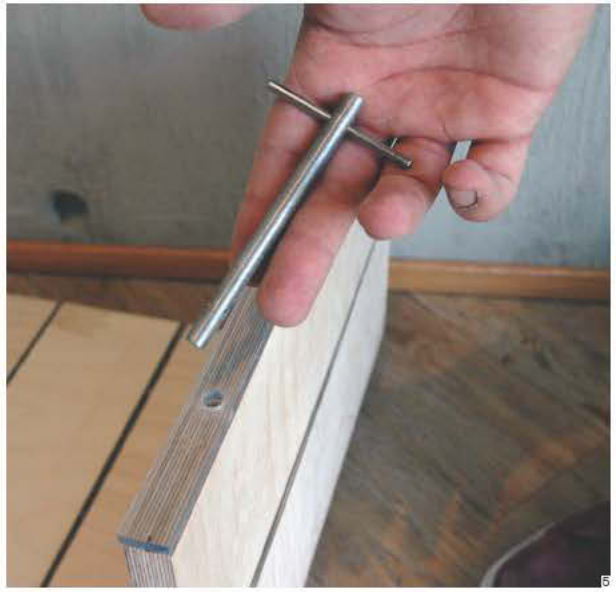
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5.1 The Finished product

The final concept

This is my concept it is a product of the prototype and my original concept. The model that I have made is very similar to this final concept.

As you can see from these renderings (image 1-3) the full intend modularity is achieved when all of the parts are identical. Shown here are what I believe are the most practical shapes

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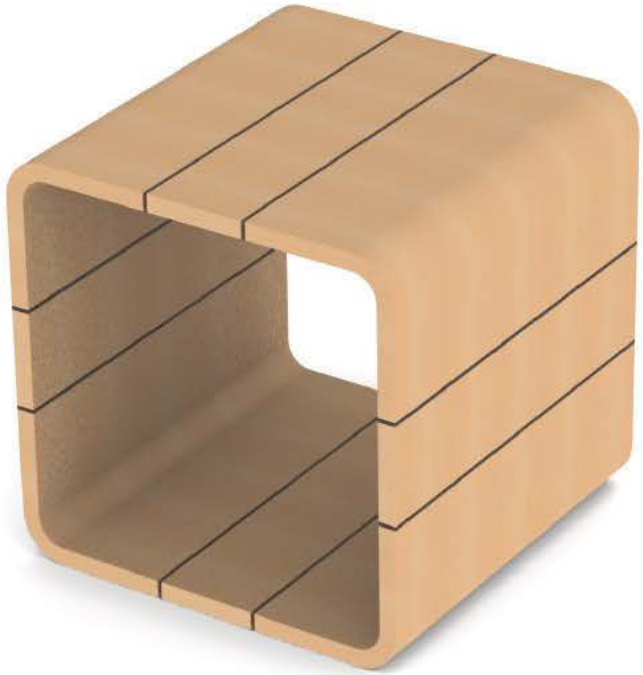
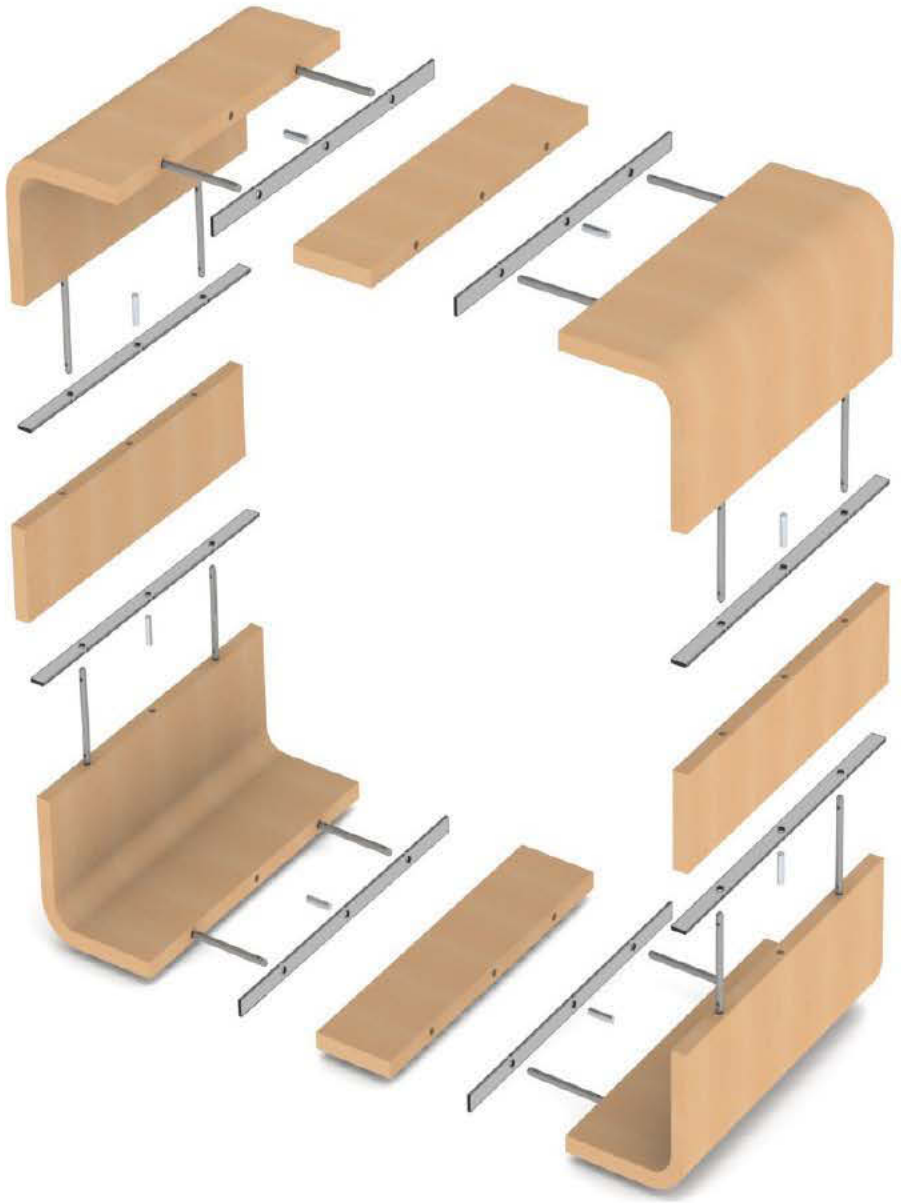


These images shows a module that has been “exploded” to show how many of the different parts there are in a completed module and where they go.

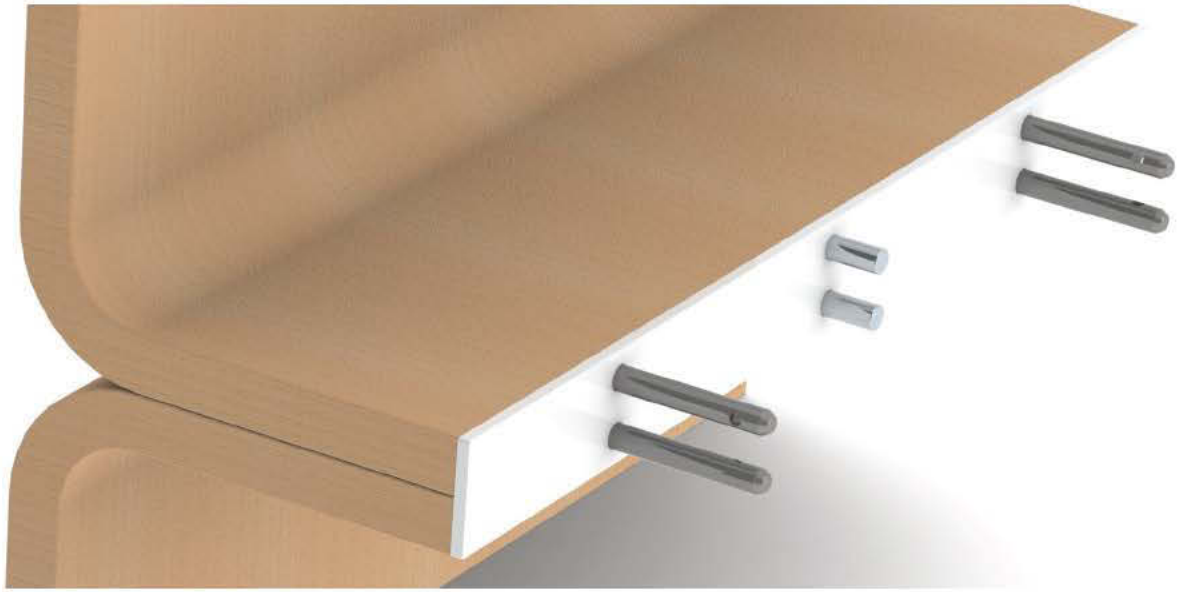


In addition to the partes from my original concepte. I have added two new parts. these partes are buffers, but hety are of either dobule height ot lengeth

These two final parts makes I possible for the users to link two of the modular boxes together either vertically or horizontally. (image 1-2)

This creates even more opportunities for the user to customise my product to suit their needs. It also means that users can create very solid and compact solutions that are safe.

2



1

The product is sold in pieces so that the buyer can buy exactly what they need and no unnesacery parts.

The basic modul is: four corners with four magnets, four lexan joints and eigth steel rods. (image 1)

Each of the different sizes that are available can be purchased in packs of two parts including 2 magnets and four steel rods. These expansions are offered in the same way as the basic module package. (image 2)

To securely attach modules to each other a link package can be purchased. Each containing two links for either vertical or horizontal joining. This can also be added to the basic module or expansion instead of two of the normal joints. (image 3-4)

The users have a choice in the colour combinations of the parts as well as the material in the outer veneer instead colour modules. The polycarbonate buffers are chosen separately so that the customer has full control over the final combination. Exsamples of these are on the next page.

1

2

3

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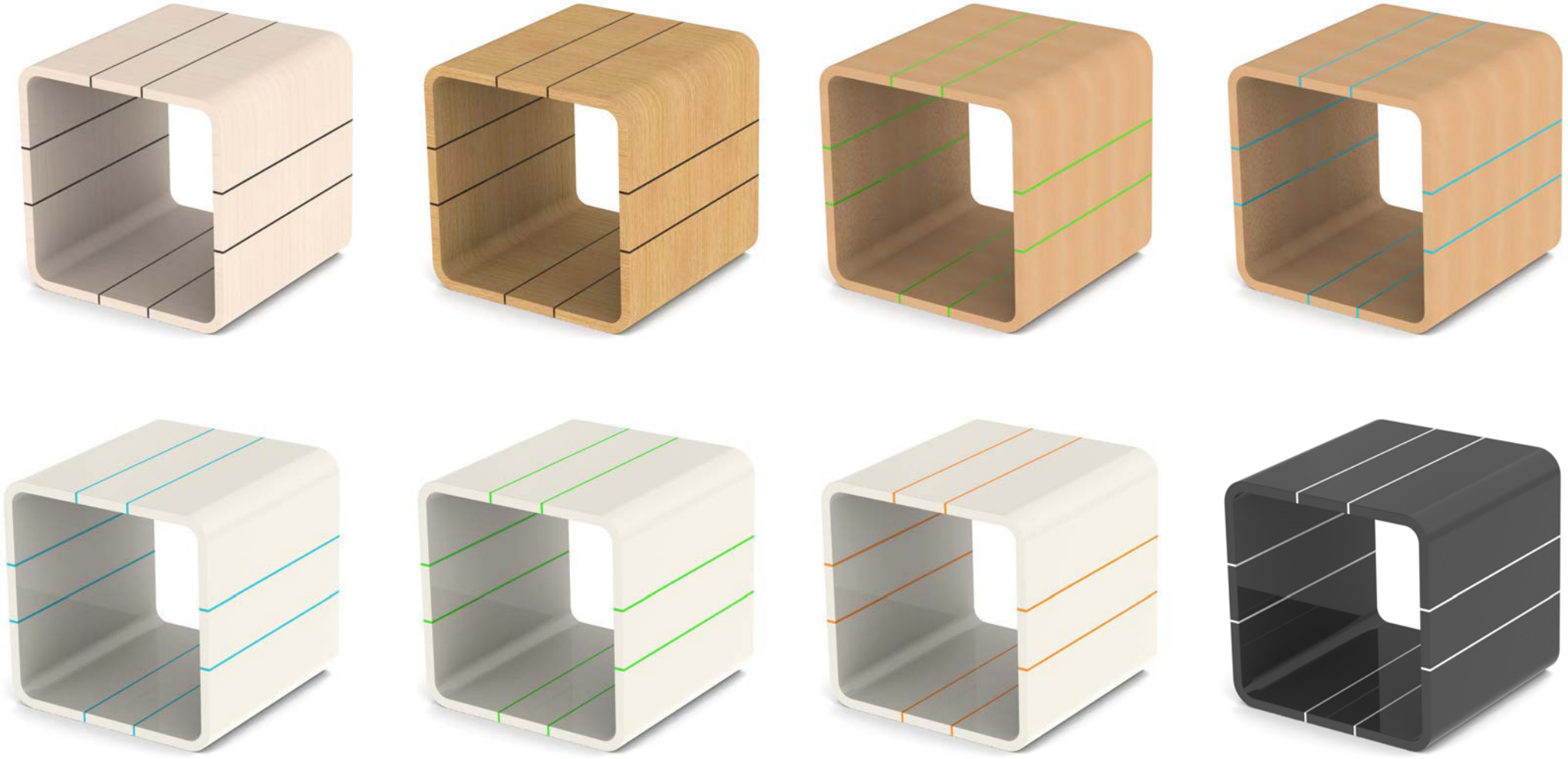


5.2 Production

Production of my product can be done on both a small scale and on a large more industrial scale. The products parts are made up of simple shapes, but they require high degree of accuracy for it to actually function as intended.

The materials involved in the parts of the product are clean and pure. This makes the materials in the product function on a “cradle to cradle” basis where all of its materials can be recycled in a material life cycle.

In a typical small-scale production of my product most of the parts will be sourced from external manufacturers. The wood parts consist of very simple shapes that a shaped veneer manufacture should already have in their product line.

The steel parts can be bought from an external machine shop. Although the parts are so simple that a simple manual tools are enough to cut a raw steel rod in appropriate lengths, which then can be machined to the correct measurements on a simple lathe or with a pillar drill.

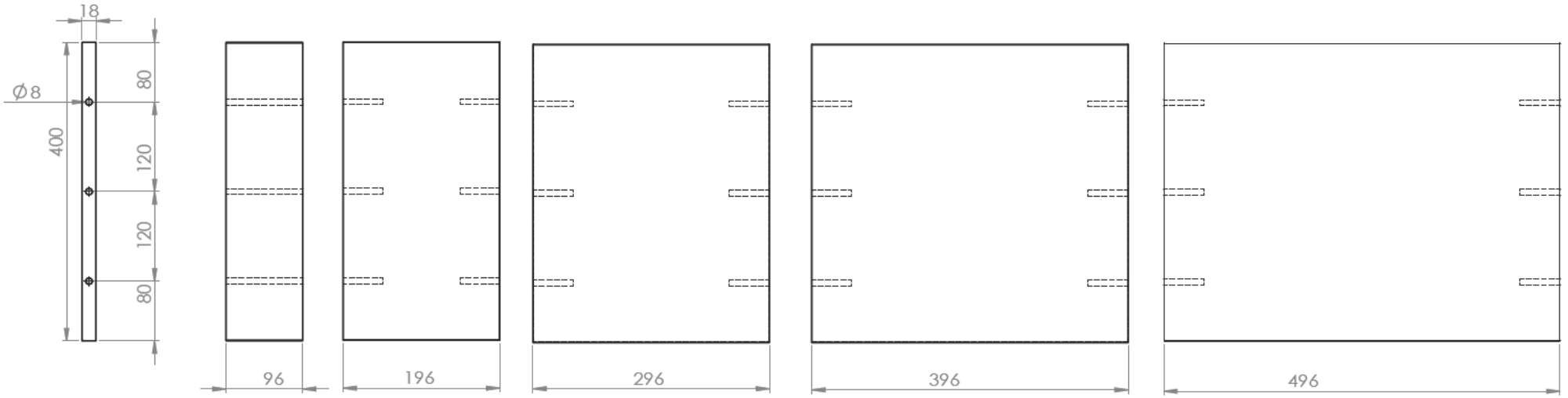
The buffers can be made from many materials, in my prototype I have used clear Polycarbonate, but I believe that one can use different types of metal or plastic to get the same effect. The material must however by at least as though as polycarbonate or stronger. The most accurate way of producing this parte is through CNC Machining or laser cutting. This service is offered by several machine shops.

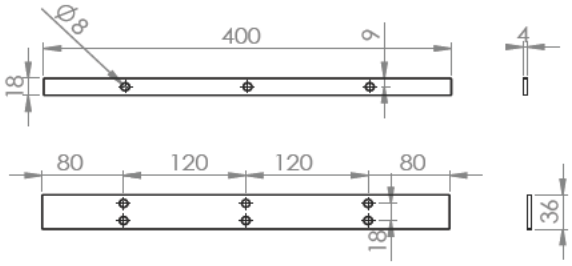
Finally the rare earth magnets are simply ordered in bulk from an external supplier.

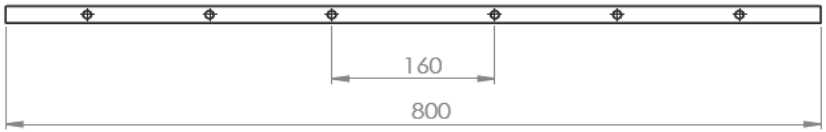
These methods can of course be used in a large-scale production scenario, although producing the parts in house becomes cheaper and easier on a larger scale.

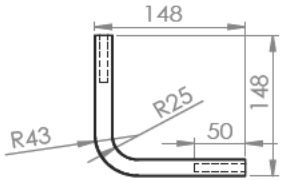
On the next page there is a measured drawing of all the parts in my drawing.

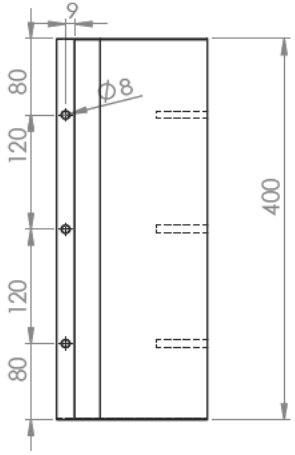
All measurements in mm

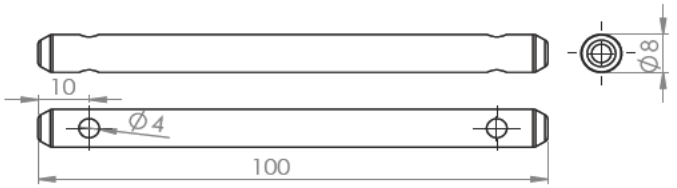












6.1 Conclusion

I started this project with a desire to create a furniture system for what I then believed where “compact living”. I wanted to build something nice and practical for small living areas.

“How can modular furniture solve the problems that arise with in compact living today and in the future?”

Through my research I understood that there where much more to the term “compact living”. I thought that living in a very small area where compact living. However compact living is to take advantage of the entire volume of space available in a living area. This is done through creative storage solutions, transformer furniture and other clever interior solutions.

In the end I identified three key features that identify compact living furniture solutions: Modular, Multifunctional and Mobile.
To validate this research I devised an experiment where I observe and recorded how people furnish a small apartment to understand how people use modules to build furniture solutions that cater for their specific needs.

The experiment confirmed the key features for a compact living furniture solution that I had identified earlier. As well as identifying a few new features such as simplicity in construction/deconstruction, Customizations in both shape and colour of the furniture.

“How are these furniture solutions possible to create with pure and recyclable materials, while being esthetically pleasing?”

As my main material and manufacturing process I choose shaped laminated veneer. This where a material and a technique which I had not worked with before, but I had always been fascinated of. Parallel with my research I did a simple material experiment to gain insight and experience in the material and the process involved in shaping veneer laminate

Through this simple experiment where I tested minimum radiuses of veneer laminate. I familiarised my self with the technique involved and the limits of the material and manufacturing process.

These two experiments and my research results formed the basis of design process where I went on to design a modular furniture system of simple parts that can be connect together without using tools.

The system creates sturdy modules or boxes which can be used as simple storage or seating. Theses modules can then be combined in to bigger solutions, which can be entirely customer, fitted to the users livening area.

The system is meant to be sold in small bundles off parts so that the user only needs to buy just the parts he need to construct his personal furniture solution.

I constructed a prototype that could demonstrate my product and concept idea. However this proto type has its limits due to several small problems with precision. The concepts success relies on the theoretical premises that any module part will fit on to any other part within the system.

To achieve this premise a high degree of precision is required. Sadly I could not be precise enough when I constructed my prototype. This meant that each module has its own set of parts that only fit to the other parts in the module and no other parts.

I did however manage to construct four of these module sets. Each of which has enough parts individually so that it can be construct into several different sizes and shapes.

This prototype combined with my experiment and research results answerers my initial research and design question to a satisfying degree.

This does not mean that my project is perfected however I can already see several faults in my current system and my prototype is far from perfect, it is only a proof of concept.

Further development can bee done with in the manufacturing process of the shaped veneer laminate to create a more precise result. A possible solution could be to order a part form a shaped veneer laminate manufacturer. The precision of the other parts and can be improved by using a CNC-router or laser cuter to precisely cut the parts or to construct a tool which enables precise manual cutting and drilling of the parts.

The measurements and shapes of the parts in the system can also be improved so that they create several new solutions, or new parts can be added to create modules that are possible to close off.

My concept of a modular furniture system is far from perfect. It is a proof of concept that it is possible to create a system that is simple yet solves some of the key issues and that arises in the compact liv ing setting.

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