Looking for paperness

Exploring the unique properties of paper

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Thank you

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for material and knowledge that made the prototypes possible

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Looking for paperness

Abstract

Paper is often used to represent architecture in models. Folded, cut, crumpled or torn the paper can have a lot of different expressions and give opportunities for both simple and advanced modelling techniques. When it is used as a representation of other materials the essence of paper often goes missing in the transition from model to full scale project. The aim of this thesis is to explore paperness, the qualities that define paper, with the purpose to get a greater understanding of how it can be applied in full scale architecture.

The thesis can be described as three phases. The first consists of meetings with people working in various paper branches the thesis is informed with expert perspectives on paper as a material, its production and use. These meetings along with unconditional hands on experiments with the material have been the starting point for the exploration of materiality and the unique expression of paper.

In the second phase three design themes are chosen: paper and moisture, the sensuous experience of paper and the modularity of the A4 format. During the third phase the findings are tested in four papery building elements: a vault, a laminate wall, a heated sitting space and a springy floor.

The knowledge gained from the early explorations created a deep interest in exploring paper as a living material, its plasticity, tension and response to moisture and temperature.

To challenge and highlight these properties the in-depth investigations have been made with a space with extreme climate conditions in mind: a sauna. The work has been a parallel process with component prototype testing and spatial sketching focusing on how the material performs and is perceived. Extra care has been put in sensational awareness and how paper is experienced by the human body.

The findings are used as a tool to design a space where paperness can be experienced. The result is a suggestion of a hands on method on how to investigate a material deeper and a series of building element prototypes that display a living material that responds to it surrounding climate.

A design that impose further questions regarding how the choice of material contribute to building design and user experience.

INTRODUCTION

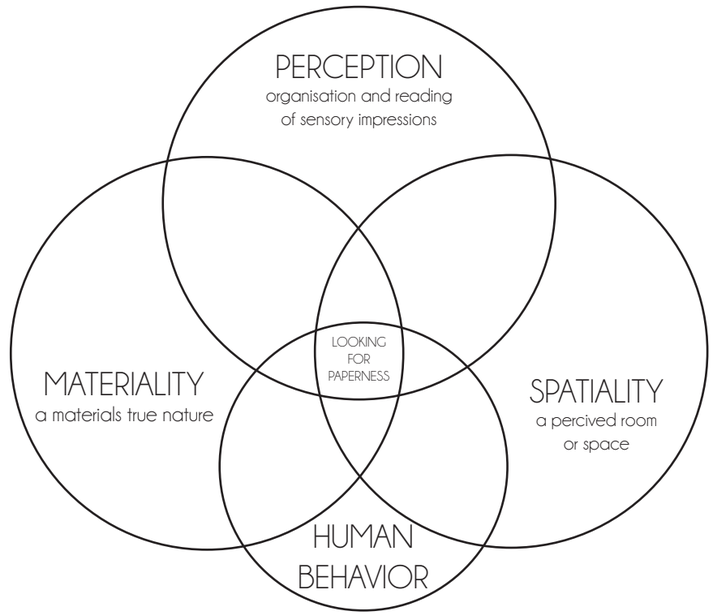
Why paper? Why us?

During our time at architecture school we have both got involved in a deep relationship with paper. In early phases we have found an unbeatable tool in paper models, helping us explore volumes and explain concepts. When not knowing how to begin, the aimless fiddling with a piece of scrap paper have helped us to get started. We experience that there is a special connection between the paper and the hand, that shapes can be formed instantly almost without passing the brain. This quick and effortless procedure sometimes lead to discoveries that maybe would not have been made if the action was carefully planned.

Paper can also be a very precise and intricate presentation tool. Carefully folded origami sculptures and representational models are only two examples of the artistic qualities of paper. The nature of paper is almost whimsical. It can be stiff or soft, it can be delicate or rugged, it can be fragile or strong. Maybe it is these contradictions that affect us?

But as the joy of working with paper models has grown over the years we have also come to develop a frustration. Somewhere in between the early sketch models and the finished proposal the paperness disappears, it is lost in translation. This made us wonder if there is a way to capture the unique papery expressions and keep it throughout the process. We believe there is!

We also believe that there is a new place for paper within the field of architecture. The digital revolution has caused a need for renewal within the paper industry and with new technology and innovations the use of paper has been broadened.



Our claim:
Paper has inherent qualities and a unique expression that can be used more within the architectural field.

"Therefore, because the nature of wood is formally different from the nature of stone, so too the forms which you give wood in the construction of a building have to be different from those of stone. Nothing is more absurd [...] than when a material is made not to signify itself, but is supposed to signify another."

CARLO LODOLI quoted by Francesco Algarotti (as cited in Poerschke, 2013, s.149)

1756

1834

"Let the material speak for itself; let it step forth undisguised [unverhüllt] in the shape and proportions found more suitable by experience and science. Brick should appear as brick, wood as wood, iron as iron, each according to its own statical laws. This is the true simplicity on which we can let our fondness for the harmless embroidery of decoration run free. Wood, iron, and every metal need a coating [Ueberzüge] to protect them against the corroding effects of the air."

GOTTFRIED SEMPER (as cited in Poerschke, 2013, s.150)

"But no, you imitators and surrogate architects, you are mistaken! The human soul is too lofty and sublime for you to be able to dupe it with your tactics and tricks. Of course, our pitiful bodies are in your power. They have only five senses at their disposal to distinguish real from counterfeit. And at that point where the (person) with his sense organs is no longer adequate begins your true domain. This is your realm. But even here – you are mistaken once more! Paint the best inlays high, high up in the wood ceiling and our poor eyes will have to take it on good faith perhaps. But the divine spirits will not be fooled by your tricks. They sensed that even those (wood carved) decorations more skillfully painted to look "like inlay" are nothing but oil paint."

ADOLF LOOS *(Loos, 1982, s.69)*

1898

1973

"You say to brick. 'What do you want, brick?' And brick says to you, 'I like an arch.' And you say to brick, 'Look, I want one too, but arches are expensive and I can use a concrete lintel over you, over an opening.' And then you say, 'What do you think of that, brick?' Brick says, 'I like an arch."

LOUIS KAHN (as cited in Poerschke, 2013, s.153)

1998

" If we work towards this goal, we must constantly ask ourselves what the use of a particular material could mean in a specific architectural context. Good answers to these questions can throw new light on both the way in which the material is generally used and its own inherent sensuous qualities."

PETER ZUMTHOR *(Zumthor, 1998, s.10)*

Our materiality

The notion of materiality can be dated to the eighteenth century. The word commonly refers to the idea of a material having its own true nature and how this is handled in architecture. How materiality is being discussed in architecture has changed throughout the years. When first being used it was the relation between the material and its structural use that revealed if a material was used according to its nature or not.

During the beginning of twentieth century two main theories on materiality can be distinguished, one with focus of the inner and one on the outer material. The inner focus on the material as structural form. The outer emphasizes how the material is being experienced with the senses. The unification of the two approaches continues to be explored in contemporary architecture. (Poerschke, 2013)

In this thesis the focus is on both the inner and the outer material. We define materiality as how a material *performs* technically and how it is *perceived* by the user. All papery explorations carried out in this thesis are evaluated from these two perspectives.

Parameters of paper:

Source of fibre

Can be Pine, Spruce, Birch, Cotton, Corn husk etc.

Mainly affects: fibre length, durability, porosity, swelling and more.

Chemical/Mechanical pulp

Chemical pulp is produced by using a sulphite process to extract cellulose fibres from wood. Mechanical pulp is produced by grinding the wood to release the cellulose fibres.

Mainly affects: fibre length, durability and strength.

Fibre length

The length of the cellulose fibre depends of its source, the way of production and if its recycled.

Mainly affects: strength and formation.

Formation

How the fibres are distributed in the paper.

Mainly affects: strength and printability.

New fibre/Recycled fibre

A cellulose fibre can be re-used up to seven times.

Mainly affects: fibre length strength, process control and durability.

Handmade/machine made

Mainly affects: fibre orientation, formation and process control.

Grammage

The papers weight per m^2.

Mainly affects: strength, thickness and weight.

Bulk

The papers thickness in relation to weight.

Mainly affects: strength and porosity.

Additives

Can be glue, clay, wax, wet strength agents etc.

Affects: opacity, strength, wet strength, durability and more.

Surface coatings

Can be glue, starch, clay etc.

Mainly affects: surface strength and printability.

Laminates

Can be thin plastic and/or metal liners.

Affects: the permeability of water, odours, bacteria and more.

What is paper?

Today, paper occur in almost any field of interest such as printed materials, packaging, technical components, arts and crafts, hygiene articles and medicines. The different uses requires different features. On the left are the main factors that affect the properties of paper.

Since paper has a wide range of properties, looks and possible uses it can sometimes be hard to separate paper form other paper-like materials.

This is how this thesis defines paper :

Content

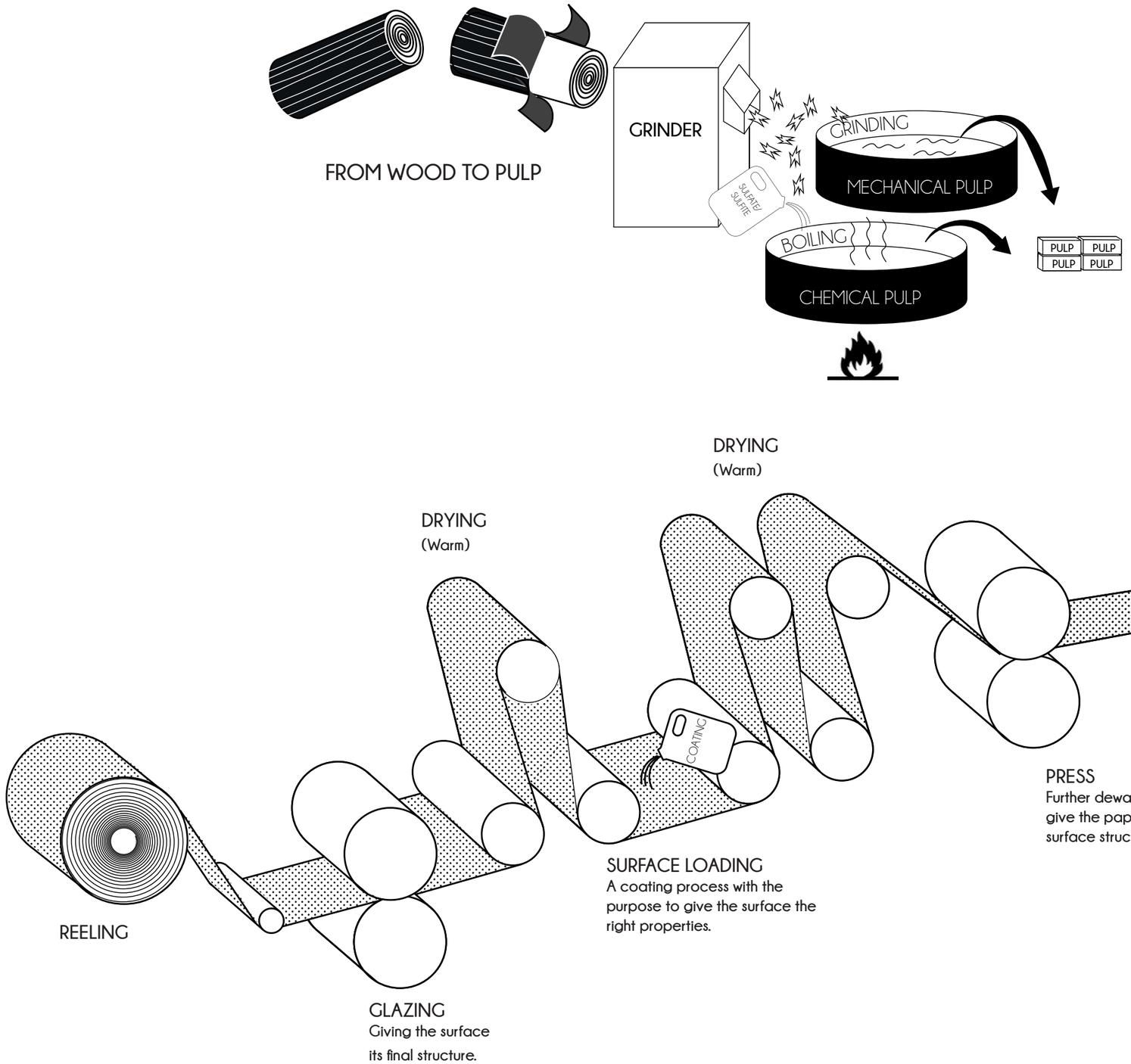
Papers main component is always cellulose fibres.

Method of production

Paper is always produced by straining the liquid away from a mix of fibres (pulp) and a large amount of water.

Format

Paper is always thin. The difference between paper and cardboard is that cardboard has a higher grammage. If it is too high it is no longer paper, its cardboard.



How paper is made

The illustration is a simplified description on the most common way to industrially produce pulp and paper. A machine like this is expensive and large quantities of paper need to be produced to bear the expense.

Today paper can be produced in up to 2000 meters per minute. This high speed affects the fibre direction since most fibres orient themselves along the paper web.

The process of making paper by hand follows the same procedure but instead of creating paper rolls handmade paper is produced sheet by sheet. A mould and deckle is dipped into pulp slush to collect the fibres. The wet sheet is then transferred to a textile cloth where the liquid is pressed out before the paper is dried. The fibres in this sheet do not have any particular direction.

Paper in architecture:

Reference projects

A summary

The reference projects are chosen because they have different approaches to how they use paper. This is done with the purpose of showing a wide perspective on what papers role in architecture can be.

Only from these four projects it's possible to distinguish some of the properties which shape the unique expression of paper.

Shigeru Ban is focusing on the structural and technical materiality of paper. Even though the sensuous qualities are observed they are not really explored further. Tacklebox on the other hand aim for a sensational experience by using a familiar material in an un-expected way. Their use is related to the connection with the tactile and sound absorbing properties. The Shoji screens combine the technical properties of the material with sensuous qualities like the diffusion of light. In Dundee Maggie's centre by Frank Gehry the paper is not used as a building material but it has informed the shape of the roof as paper has been used as a sketching tool.

All this examples of using the material are connected to how it performs technically and/or how it is perceived. We think that there are possibilities to make more papery projects that intertwine the aspects just mentioned and display even more papery properties.

How the paper performs:
The paper tube works well in compression when standing upright.

How the paper is perceived:
The expression of the paper tube is almost similar to a log or concrete pillar but the smooth surface gives a papery tactility.

Photo: Hiroyuki Hirai

Paper house Lake Yamanaka

Site

Yamanashi, Japan

Architect

Shigeru Ban Architects

Size

100 sqm

Use

Housing

Time perspective

Built as a permanent structure.

Context

The building is situated by a lake in Yamanashi, it is designed to have a close relation to its surrounding rich nature.

Paper type

Paper tubes made of recycled paper.

Papers role

In this minimalistic approach the paper tubes are the main actor of the impression of the building. The color of the paper create a warm atmosphere. Its structural task becomes clear to the visitor through the design.

Papers expression

A solid expression reminding of timber logs.

Papers surface

The paper tubes have a smooth surface with a matt finish.

Papers structure

Ten paper tubes support the vertical load and eighty interior paper tubes bear the lateral forces.

Joints

The tubes have wooden joints that are anchored to the foundation by lug screws.

How it sits on the ground

The the tubes are cantilevered from the floor.

Paperness

Looking at photos it is not clear that the columns are made of paper. Maybe if one experienced the building in real life the matte surface of the paper tubes would add a sense of paperness. The focus in the project haven't been on materiality. The reason for why Shigeru ban begun using paper in architecture is because of it's low cost and sustainability.

How the paper performs:
The paper is used as a plastic sketching tool.

How the paper is perceived:
Even though paper is not a building material the roof gets a light and crumpled papery shape.

Photo: Ydam

Dundee Maggie´s Centre

Architect

Frank Gehry, 2003

Size

250 m2

Use

The building is designed as a Cancer care center where patients can spend time in a less sterile environment.

Time perspective

This is a permanent building

Context

Placed in a Hospital park, Dundee, Scotland

Paper type

Drawing paper and cardboard is used to create sketch models.

Papers role

In this project paper is used as a sketching tool to inspire expression, shapes and volumes of the finished building. The paper models are not used as representation, but as a way to test and manipulate the design in a intuitive way before being transferred into a digital model.

Papers expression

The roof is shaped as a folded/crumpled sheet of paper. The facade has a smoother expression, generously interpreted as a bent or rolled paper.

Papers surface

The sheets of paper in the model is in the finished building translated to sheets of stainless steel in the roof and white plaster walls.

Papers structure

There is no actual paper in the finished building but the thin paper like expression of the roof is somewhat contained by using a wooden structure that let the edges of the roof stay “paper thin”.

Joints

-

How it sits on the ground

Quite heavily

Paperness

The effortlessness of the paper sketch models is not completely contained but there are still traces of paperness left in the roof which seem to almost be crumbled by hand. The double curved surfaces makes it less papery.

How the paper performs:
In this project paper is not used because of its technical performance.

How the paper is perceived:
The familiar paper bags create a textured wall that encourages the visitor to playfully interact with the paper. Touching the bags gives a dry sound and tactile experience.

Photo: Juliana Sohn

Boutique for OWEN

Architect

Tacklebox architecture

Size

Interior design project, sqm unknown

Use

Fashion retail store

Time perspective

Temporary

Context

A boutique in New York City's meatpacking district, high end but hip fashion store.

Paper type

Brown "to-go" paper bags.

Papers role

The temporary interior is designed to be a physical introduction to the identity of the brand. In the storytelling of the brand the paper bag is used to create an environment that is unique and surprising yet very familiar. The designers have been inspired by the owner's sense for detail and handmade fashion. The paper bags are a big part of creating the atmosphere but also act as a noise absorbent.

Papers expression

The 25 000 paper bags attached close together create a uniform volume with an organic, 3-dimensional expression.

Papers surface

The open top of the bags creates an interesting surface. Close up one experience the hollow space of the empty bags. On a distance the surface of the bags looks more like a solid wall with an honeycomb-like structure.

Papers structure

25 000 paper bags are attached to a board that bends and becomes a half arch that meet the opposite brick wall.

Joints

Unknown

How it sits on the ground

There is a small distance between the paper bags and the floor.

Paperness

The designers were looking for a material that suits a temporary structure that is surprising yet familiar. By using paper, a material that everyone is familiar with in a new way they create what they are aiming for. The easy access of paper and its cheap price suits a temporary structure well. The paper is used in a way so that its tactile and hands on qualities are present. The visitors can touch and experience the material which associates with the brands focus on detail and handmade craft.

How the paper performs:
The paper screen lets diffuse light through and helps regulating room temperature and moisture levels.

How the paper is perceived:
Depending on the light conditions the papers formation is visible and the screen has different levels of transparency.

Photo: Alex Ramsay

Shoji screen

Architect

Traditional Japanese interior design element

Use

These paper thin sliding doors are used to define space and divide the room.

Time perspective

Usually requires a yearly maintenance due to its fragile composition. The paper screens are easily ripped or damaged by poking fingers.

Context

Japanese homes, tea houses etc.

Paper type

Washi paper: a translucent paper usually made from the pulp of Japanese mulberry tree, traditionally by hand.

Papers role

The paper screens were used long before glass was invented and appreciated for is ability to let the light through and providing a even room temperature. They are also absorbing humidity during winters.

Papers expression

The paper is mounted as a flat sheet onto the screen. The light get warm and dimmed when passing through te paper, giving it a soft glow.

Papers surface

Traditionally the surface of washi paper is quite rough and grainy.

Papers structure

The paper sheet is glued to a wooden frame with wooden/ bamboo splines and then sprayed with water and left to dry. This process makes the paper shrink and tightens up the construction.

Joints

Nori glue is used to attach the paper to the frame. The glue is based on rice starch and dissolves when wetted. This feature makes sure that the maintenance will have a tidy result.

How it sits on the ground

The frames are put in a top and bottom wooden rail and allowed to slide freely. The frames can be lifted out of the rails in order to allow the room to grow into a bigger space.

Paperness

The thin paper sheets provide a special paperness regarding light, surface and sound. The usually rough and uneven nature of the paper gives a hint of the papers composition and diffuses the light from outside, creating a very special atmosphere. Unlike translucent glass panels, the shoji paper are not particularly good at keeping the sound out which gives the room a tent like sound experience.

Paper in architecture: Technical challenges

When searching for the qualities that define paper one method was to pinpoint its technical challenges and possible ways to handle them or even make use of them.

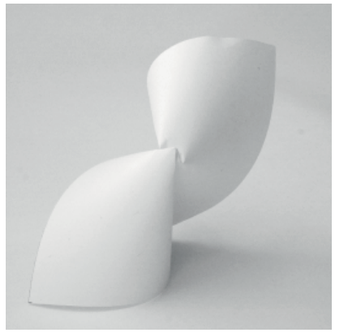
We outlined the properties we found most challenging and made a text table with an action plan for different scenarios. The table have been a tool during the process to clarify and understand our decisions.

PROPERTY	*DESCRIPTION*	*LIMITATION*	*ACTION ALTERNATIVES*
PLASTIC	Can easily be modified by hand and keep its shape.	Can be deformed by users, infestations and force of nature.	Allow the intervention to be deformed. Make the intervention easily repairable. Put the intervention in a place where it can not be reached. Make the intervention temporary and remove it when too deformed.
FRAGILE	Easy to rip and perforate.	Might break while handling. Holes and rips can occur in contact with curious users or infestations.	Make the intervention easily repairable. Use kraft liner paper, thick paper and/or laminated paper for more durability. Put the intervention in a place where it can not be reached. Make the intervention temporary and remove it when it is too damaged.
POROUS	Absorbs liquids	When wetted, paper can lose its shape/ strength and break. Easy to stain. Adapts to surrounding humidity and swells/ shrinks.	When designing structure and joints, be aware that the material will move. Accept the fact that the intervention will be stained and work out a way to handle it. Use kraft liner paper, treated paper or laminated paper for more durability. Put the intervention in a place where it is not in direct contact with liquids. Make the intervention temporary and allow it to dissolve.
FLAMMABLE	Can catch fire	Can be destroyed by heat, flames and sparks.	Use flame retardants. Make the design burn slowly if catching fire. Make the intervention temporary and design it to burn without risk.

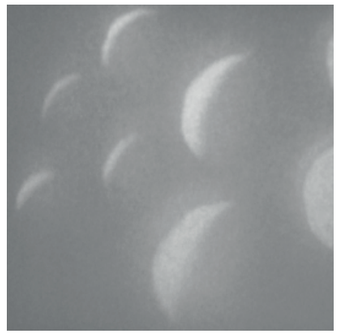
PHASE ONE: FINDING PAPERNESS

To look for a materials true nature is a personal task and there is not one right answer. Since paper is a familiar material regularly used by almost everyone our personal experience and memories of paperness is almost subconscious and hard to put in words.

To deepen our understanding and create our own definition of paperness we have been alternating between making paper prototypes and meeting people working with paper in various ways. This resulted in a collection of words that has been growing along with our process as we have been making deeper material investigations.



PLASTIC+TENSION+LIGHTNESS

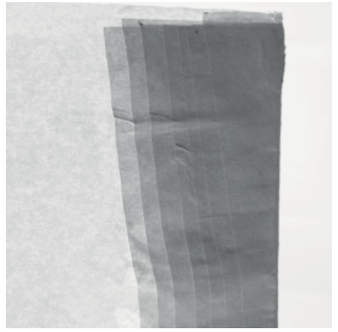


TRANSPARENT+LAYERED+LIVING

CONSTRUCTIVE+ABSORBING+CRAFTY

SPRINGY+PLASTIC+TENSION

RUSTLING+TENSION+FLIMSY

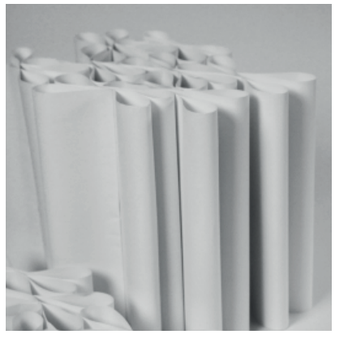


TRANSPARENT+THIN+LAYERED

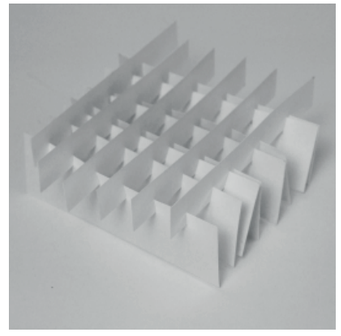
FORMATION+RELATABLE+HANDCRAFT

PLASTIC+THIN+CRAFTY

ABSORBING+CRAFTY+PLASTIC



PLASTIC+SPRINGY+CONSTRUCTIVE

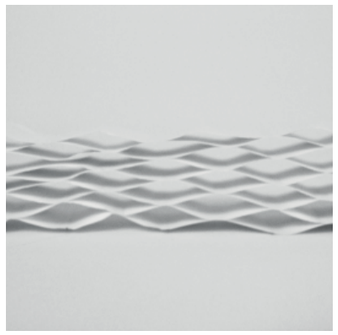


CONSTRUCTIVE+LIGHT+FLIMSY

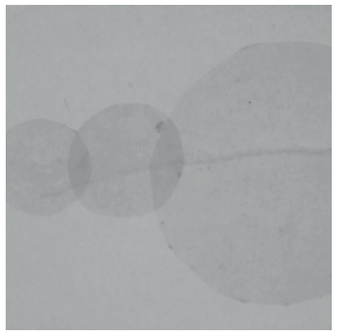
ABSORBING+POROUS+SWELLING

FRAGILE+MATERIAL MEMORY+PLASTIC

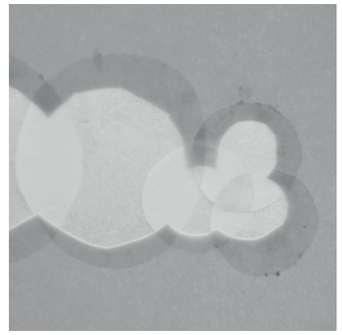
FLAMMABLE+THIN



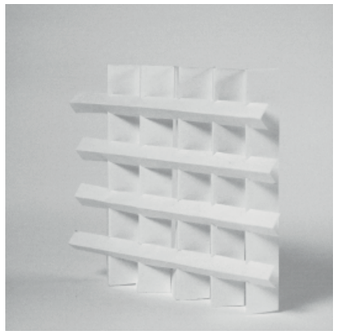
SPRINGY+FLEXIBLE+LIGHT



RRRRRRITSCH+FRAGILE+TRANSPARENT



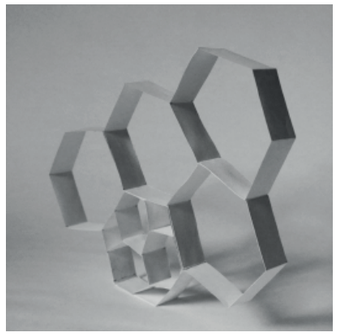
THIN+LAYERED+TRANSPARENT



LIGHT+PLASTIC+CONSTRUCTIVE

TENSION+PLASTIC+STIFF

MATERIAL MEMORY+PLASTIC+TENSION



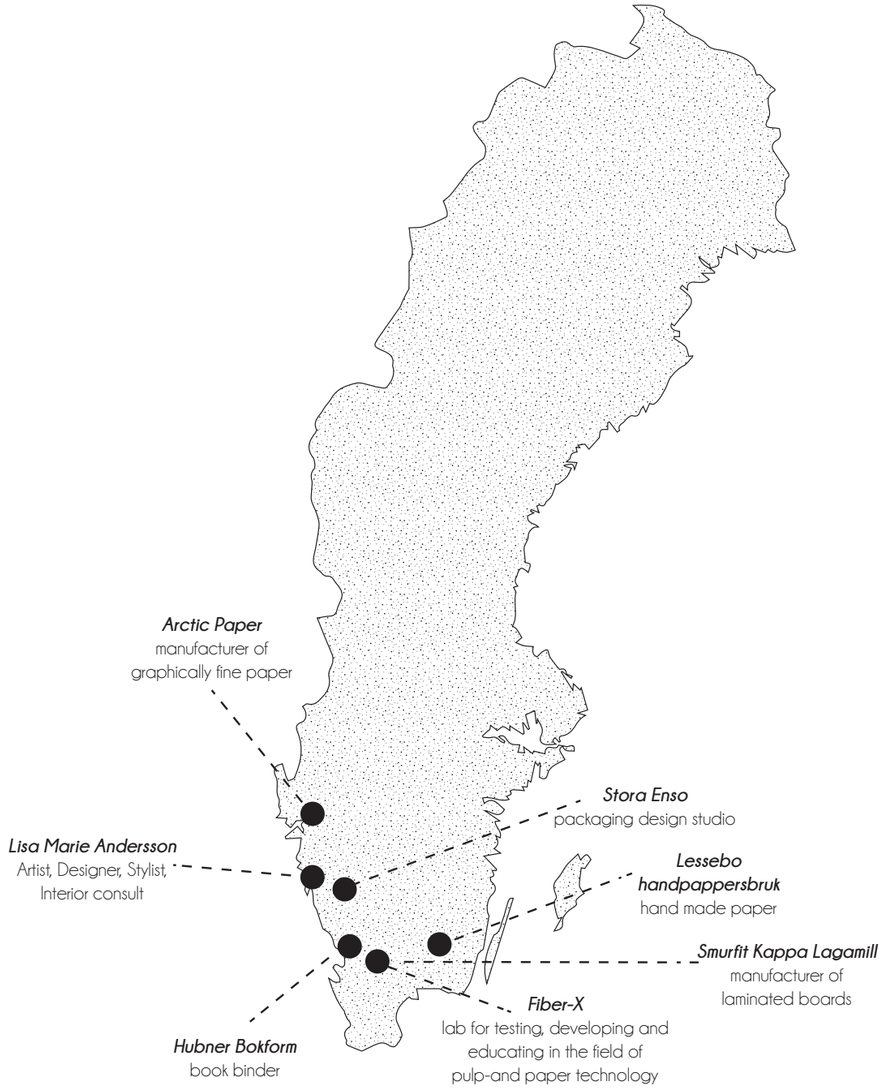
FOLDABLE+LIGHT+TENSION

TRANSPARENT+THIN+FORMATION

Early explorations

The point of departure for the early explorations were exploring the material through three themes: surface, joints and structure. This themes were a good way to start but became blurry fast since they are overlapping each other.

We started of with the basics by making our own paper out of old newspaper magazines. Then we continued our explorations by applying different techniques with the material. We pierced, burned, folded, cut, wetted, glued, sewed and crumpled the paper in the search of it's specific properties.



Meeting paper nerds

Paper is used in a wide range of professions that are all paper nerds in different ways. By making field trips to their worlds, our understanding of paper has deepened. We've had the privilege of entering the worlds of the handmade paper artisans, the modern paper mill industry, a packaging designer, a bookbinder, an artist and a laminating factory.

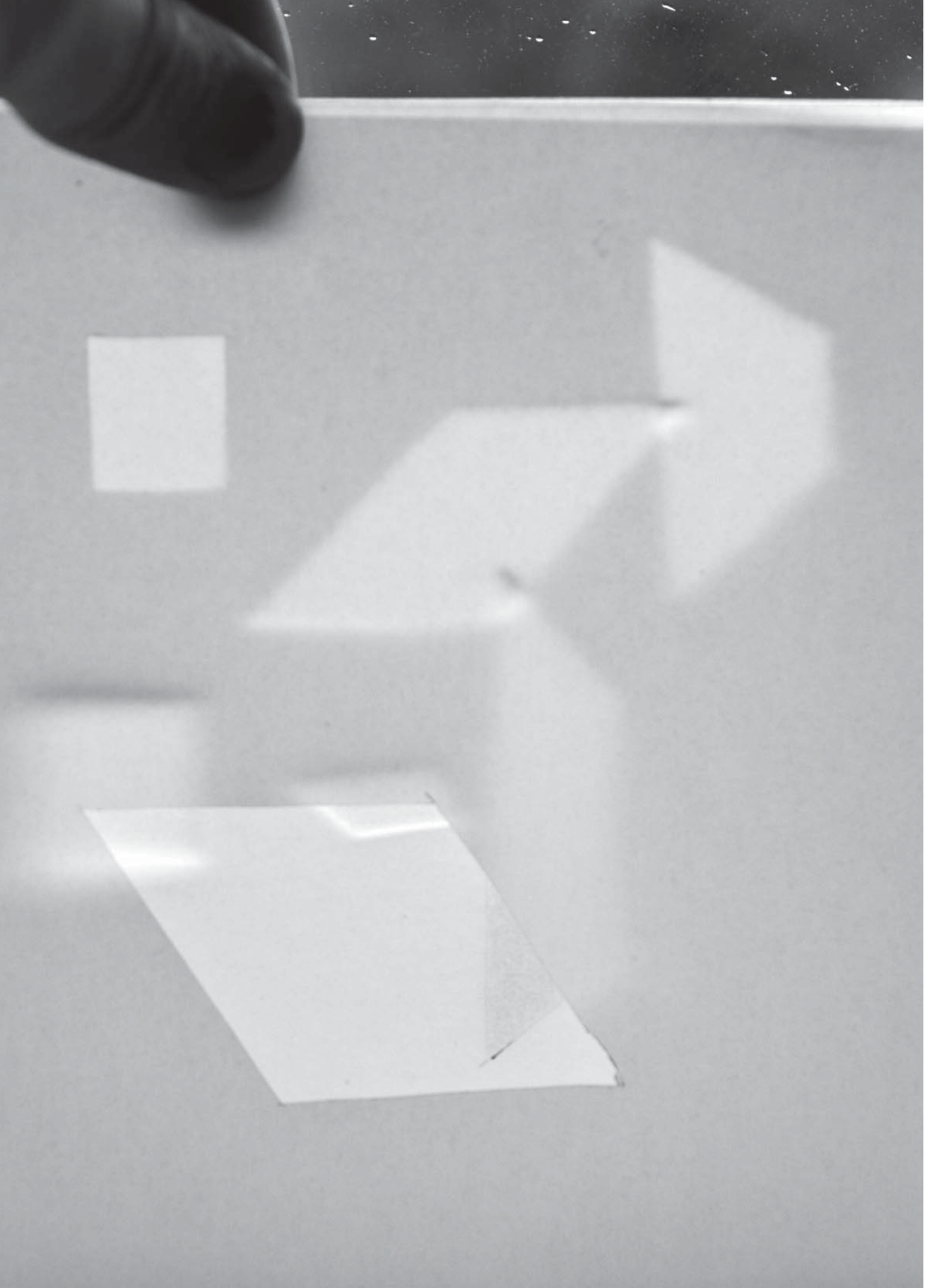
When asking about what make paperness we have rarely got a direct answer. When the conversation about paper instead was free to flow many answers to the same question was given. Paper is a complex material with many properties. One of these properties that all the professions deal with is that it is a living material that responds to its environments level of humidity.

Field trip to

Lessebo hand paper mill

Lessebo handpapersbruk have been making handmade stationary since 1719. Today the mill has two employees practicing the craftsmanship of making paper by hand. The paper being produced is of fine paper quality, usually a mix of cotton and linen, at times only of cotton. The paper sheets are used for example as diplomas, documents that needs to have archival stability and aquarelle paper.

At Lessebo handpappersbruk we got to follow the process of forming, drying and pressing handmade paper. We learned about what impact the fibre type have on the finished paper sheet and what the differences are between a handmade paper and a paper produced by machine.
The difficulties of making many paper sheets with equal properties and the skills it requires became clear to us.



Focus prototype

Layers+transparency

After learning the basics about paper we started experimenting with its transparency. First we looked at different fibre types and how they diffused the light. Soon we started experimenting with layering many sheets to create a sense of depth.

How the paper performs:
The prototype shows papers light diffusion qualities and the plasticity of how easy the transparency can be adjusted by the number of layers or choice of fibre and grammage.

How the paper is perceived:
By adjusting the distance between the layers the appearance of the cut-outs changes. When close they look very sharp and when further away they get blurry.

Field trip to

Arctic paper

The Munkedal mill in which Arctic paper houses origins from 1871. They produce graphic fine paper for printing matter, both uncoated and coated. The qualities range are standard, graphic and premium. Two paper machines produce 225 ton paper a day.

The visit at Arctic paper included a lecture/conversation with experts about the process of making paper and also a walk-through in the actual factory. Besides learning more specifically about the different parameters and components that make paper, we were amazed by the beautiful site by Örekilsriver and intrigued by the machines. It's fascinating how the machines make it possible to manage every small step of the process in detail.

Field trip to

Stora Enso packaging design studio

The packaging design studio at Stora Enso is specialized in designing corrugated cardboard boxes. Since their clients are very different there are no such thing as a “standard box”, every package design is adapted for its special purpose regarding strength, durability, wet strength and visual expression.

We were introduced to some basic design strategies regarding joints, strength and stability and got to see how a thin PET-film can affect the water sensitivity of the material. A discussion about paperness was also interesting since the properties of the paper they work with are very diverse.

Field trip to

Smurfit Kappa Lagamill

Smurfit Kappa Lagamill is a factory specialized in laminating solid boards. The types of solid boards that is made are very specific depending on the properties that are wanted. Example of products are packaging for containing fish, security packaging for syringes and fruit and vegetable packaging.

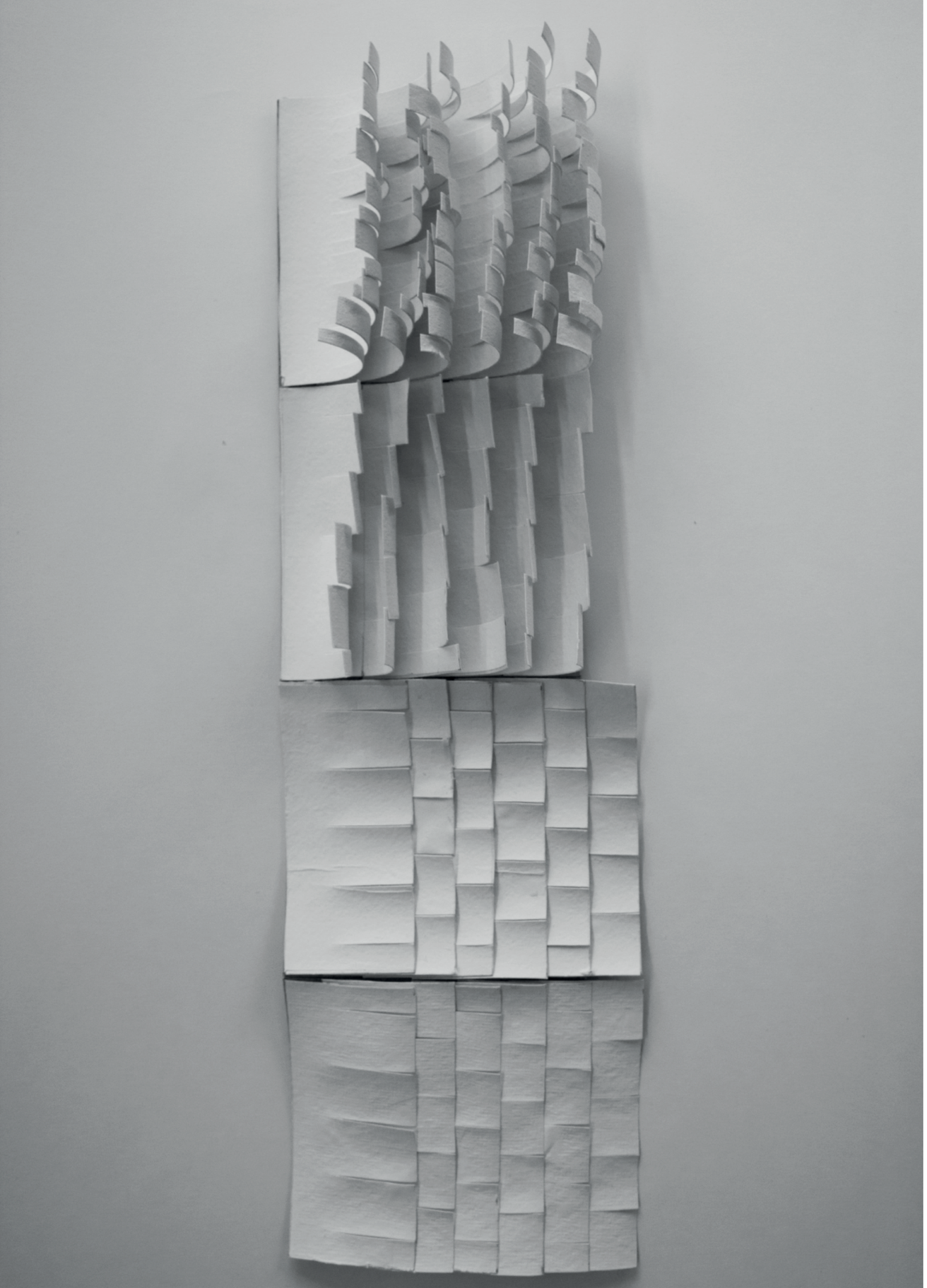
In contrary to the other field trips we visited Smurfit Kappa Lagamill later on in our process since we had specific questions concerning laminating paper sheets. At the visit we got an introduction of the company, a walk through the factory and time for specific questions on laminating techniques. We talked to persons involved in different parts of the production process and got the chance to discuss detailed theories on laminating techniques and how to enhance the curling of the laminates that we had been experimenting with.

Field trip to

Fiber-X

The company is specialized in developing and educating in the field of paper technology and pulp-industry. With the deep knowledge and it's network with other people in the industry Fiber-X is a platform for helping companies making prototypes of new ideas.

Fiber-x have it's own paper machine and a laboratory for making tests. We got a walk thorough the facilities and time to talk to the owner Heikki Sojakka. This meeting was held after half time of the process which meant that we could discuss detailed theories on laminating techniques.



Focus prototype

Curly laminates

The knowledge from these four visits made us experiment with laminating machine produced paper with hand made paper with the purpose to make it deform. We wetted the two papers and glued them together. Their different fibre properties made them curl when dry.

How the paper performs:
This laminates shows papers plastic, porous and absorbing properties If you soak the laminate again it will straighten and then curl again when drying.

How the paper is perceived:
The laminates are perceived as transparent and thin, the short time span of the curling movement make it possible to see.

Field trip to

Hübner bokform

Hübner Bokform is a book artist gallery and bookbinder workshop. The owner and founder of the workshop is the bookbinder Per-Anders Hübner who works there together with an apprentice. Together they perform all types of manual bookbinding work such as: new binding, file binding/lint binding, dummy manufacturing and much more.

During this visit, we got a small glimpse inside the world of bookbinding. It deepened our understanding of paper and the importance of handling it with knowledge. We learned about the difference between glue and paste, about the different steps in the process of binding a book and got suggestions on how to bind our thesis booklet. We got to try bookbinding and see how a professional handle the material.

Focus prototype

Glued spine

At the bookbinder Hübner bokform we especially got to learn about different types of joints, glue and paste. And how to make a durable binding by bending the book and glue the spine

How the paper is perceived:
This gluing technique gives a strong, rather stiff binding.

How the paper is perceived:
The glue is one of the joineries most deeply connected to paper.

Field trip to

Lisa Marie Andersson

Lisa Marie is a designer, stylist and interior consult. During the recent years her focus have been on working with paper art and origami. She folds paper geometrically by hand to form paper art pieces. She has also done commission paper art work for different types of companies like Arctic paper, SKF Marine and Sandberg Wallpaper.

At our meeting with Lisa Marie she described her creative process and what papers she prefers to work with and why. We talked about small details like certain type of folding technics, and preferred glues but had also a wider conversation about paperness and what properties that are unique for the material.

Focus prototype

Massive fold

This prototype derives from a wish to make less fragile folded prototype. In this solid piece ⅓ of each sheet is folded to make one end of it is thicker than the other and becomes the start of a solid paper vault.

How the paper performs:
The stacked sheets works well in compression but not at all in tension.

How the paper is perceived:
The compressed folded sheets give a special texture when touching the sides of the prototype. It is perceived as heavy and layered.

PHASE TWO: DECIDING FOCUS +PROGRAMME

THREE DESIGN THEMES

- a way to choose a programme

PAPER+MOISTURE

Papers ability to absorb liquids is an essential papery property and that is also one of the main argument for why using paper in architecture could be problematic. Can it be used to enhance the design?

PAPER+MODULARITY

Using the familiar and affordable A4-format as a modular system.

Deciding a programme

As a method for narrowing down and focus our further investigations we decided on a programme for our intervention, a sauna.

We found a sauna intriguing since it gave us a chance to work with a great span of moisture levels and to challenge our own perception of what is possible to build with paper.

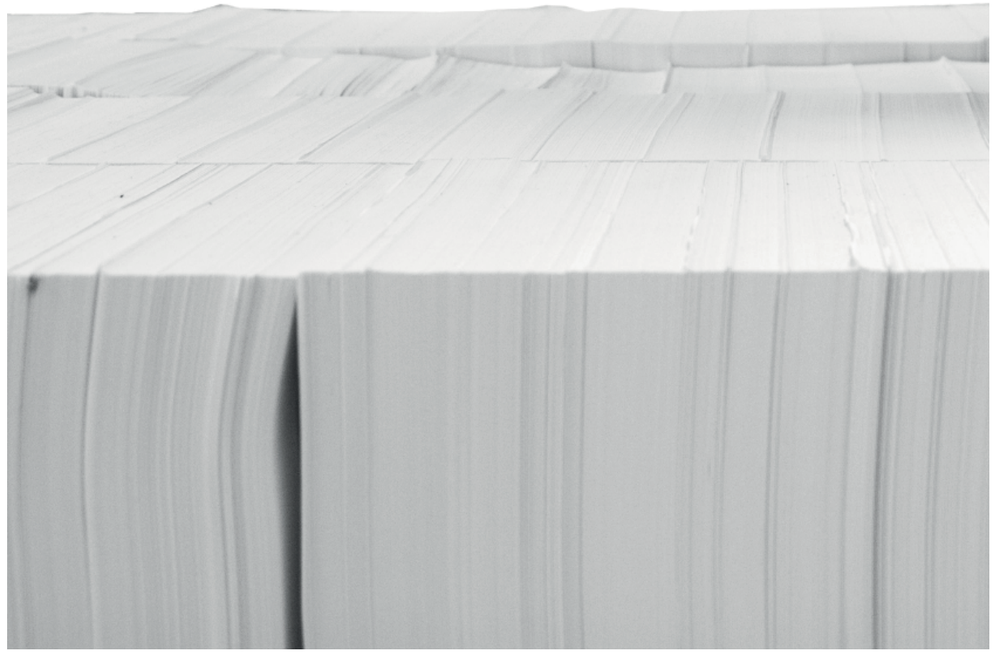
It is also a space suitable for paper sensations since the body is close to the material.

A sauna needs this

When working with the sauna we have been discussing its function and its components and what the bare minimum of a sauna is. Does it need a floor? A shower? An entrance? A bench?

By researching different kinds of traditional saunas we have found a great variation regarding construction, appearance and rituals. What they all have is a heat source to warm up the air and a building envelope to contain the hot air. The most primitive saunas we found are sweat lodges, tents, usually simple structures covered with blankets, warmed up by stones heated in open fire.

The design process starts off with an exploration of how a heat source and a building envelope can be papery.



Design concept,
General:

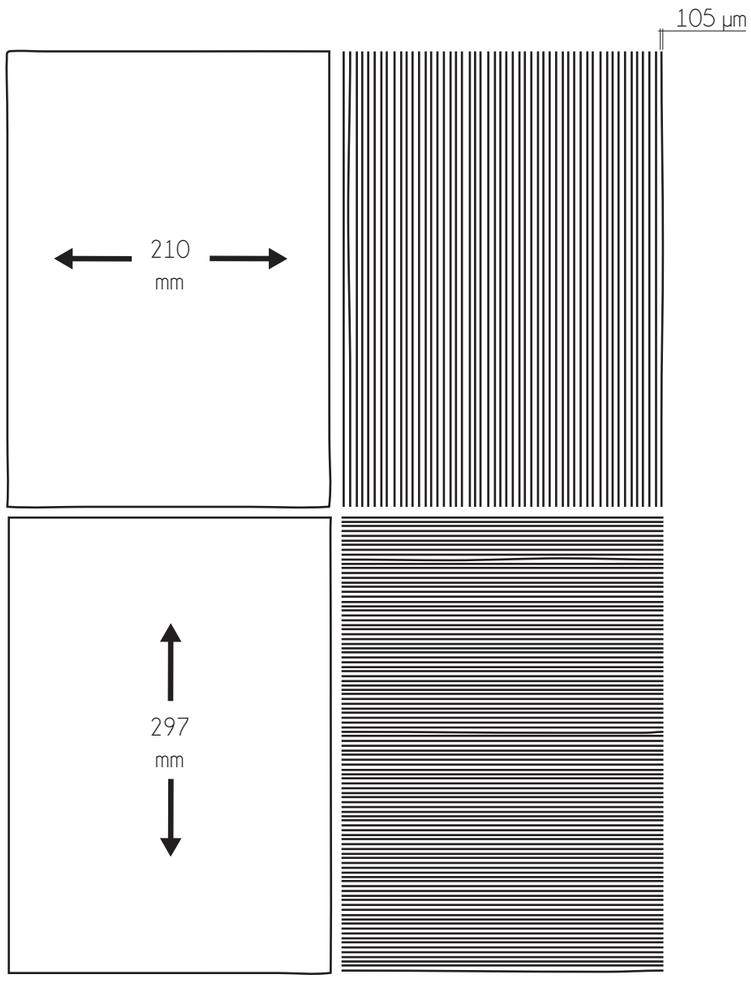
Heavy and solid + Light and thin

The two main components of the sauna, the heat source and the building envelope, are the departure of our design.

The concept of the heat source is to use compact massive paper to store the heat.

The concept of the building envelope is to make thin laminates that react to the moisture and diffuse the light.

Together they show the contradiction of paperness, that it can be both heavy and light, fragile and robust, tense and relaxed.

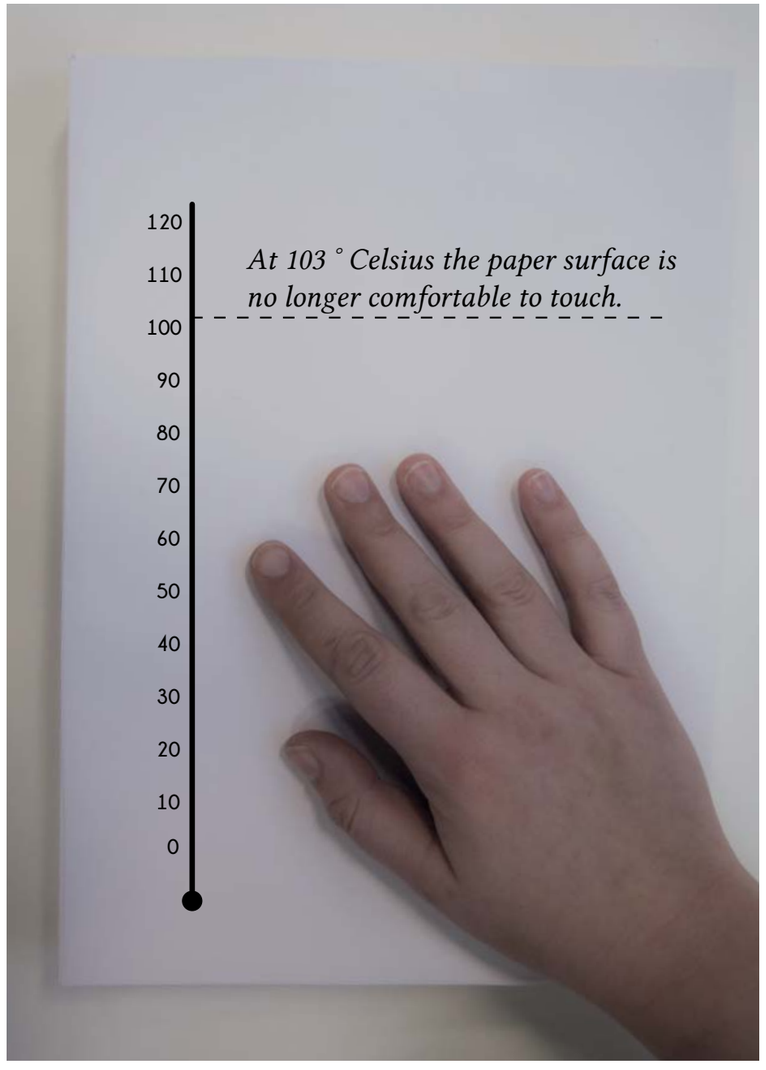


Design concept,
Heat source:

Solid modules

The point of departure was the question “Can paper itself be the heat source?”. This led us to the concept of solid modules. While investigating the thermodynamics of paper we explored the idea of massive paper as the heat source and discovered its potential as a floor and seating space.

We have chosen to work with the regular A4 printing paper since it is accessible and has a size that is easy to handle. The experiments provide new perspectives on a familiar format and its modularity.



Heated paper

How the paper performs:
Paper insulates and store the heat well.

How the paper is perceived:
Warm paper feels nice to the skin up to a surface temperature at about 100 degrees Celsius. Warmed up paper emits a papery scent.

Bundle on fire

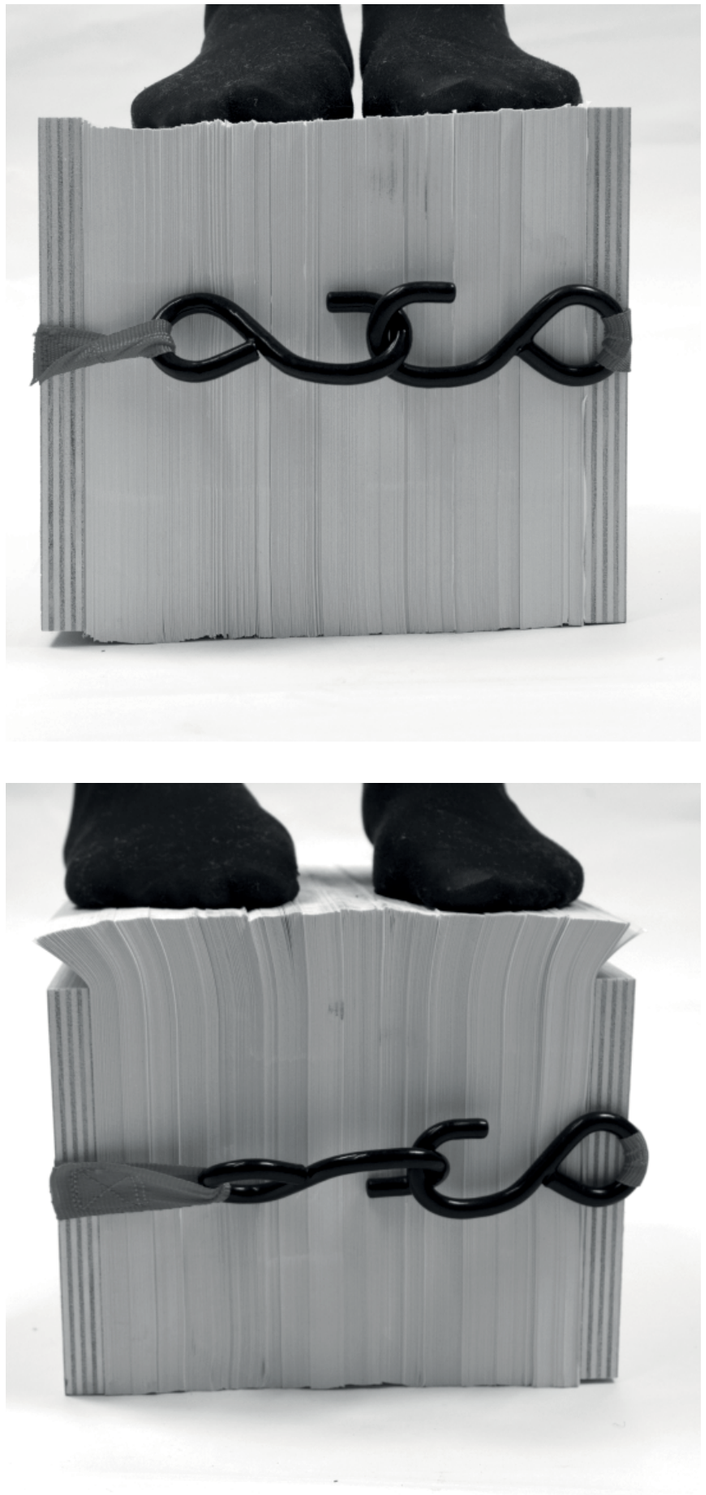
How the paper performs:
Paper tightly pressed together does not easily catch fire because of the lack of oxygen and that printing paper contain a lot of chalk. This makes the paper glow slow and evenly. The paper insulates well and the top was still possible to touch without getting burnt.

How the paper is perceived:
The paper is still OK to touch for a long time, and has a nice warm feeling. The smell of burnt paper is nice at first but gets sharp in the long run.

Integrated heat source

How the paper performs:
Since the insulation of paper is so good, just a thin pile of sheets will make the paper OK to touch/sit on even if the heat source is very hot. In this experiment a 150 degrees Celsius heating foil was placed 7 mm into the stack and made the surface temperature 37 degrees. Since printing paper can endure up to 350 degrees a better heating foil is a possible way to get a warmer surface temperature.

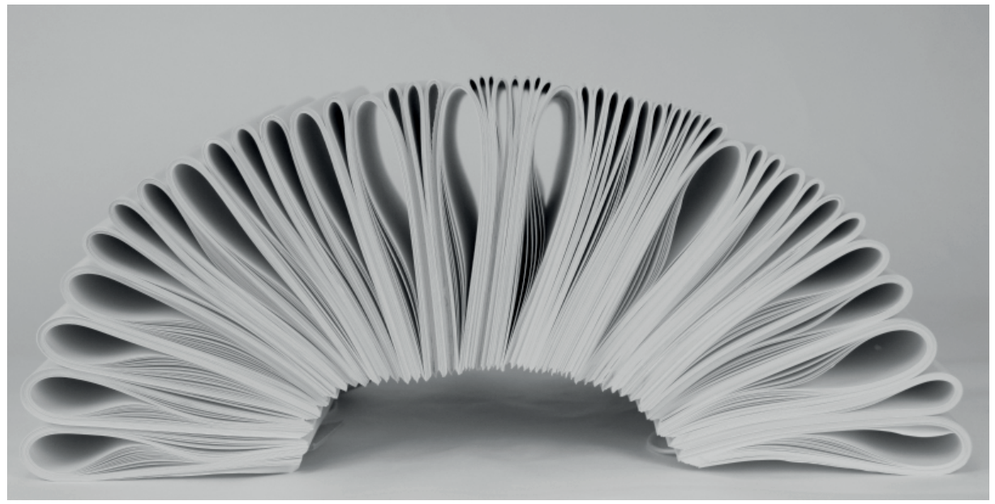
How the paper is perceived:
The warm, smooth surface is pleasant against the skin and give off a papery scent. Using glue on two sides of the stack gives one stiff corner and one loose corner that responds to humidity.

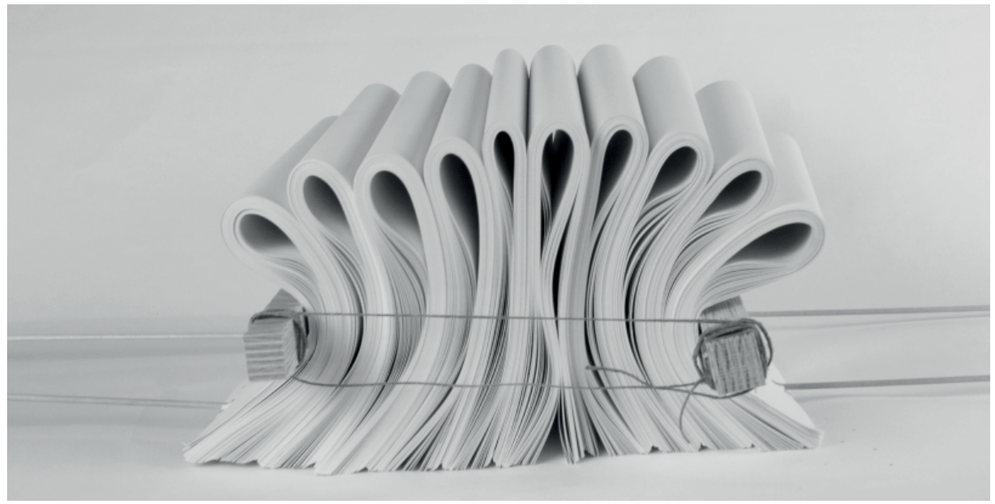


Springy Floor

How the paper performs:
A paper bundle can stand vertically and endure heavy point loads if pressed tightly together. Depending on the height of the wooden gables the paper moves under pressure.

How the paper is perceived:
The bundles creates a springy irregular texture which makes you aware of your body impact on the material. You feel the edges of the sheets without getting
paper-cuts.





Paper vault

How the paper performs:
When joined together, folded small paper bundles will create a vault structure. In this scale the thickness of the creases defines the shape but it collapses under point loads. The holes are made when the paper bundle is flat. When the bundle is folded the position of the holes shift and the joinery gets wearying and hard to tense.

How the paper is perceived:
The forces becomes visible to the eye and also possible to feel by touch. You experience how the folded bundles are more compressed in the middle and more loose on the sides.

Bundle screw joinery

How the paper performs:
This joining technique that is rather simple and quick. The bundles get stiff and stable under pressure. This technique makes it possible to create continuous stacks while it allows the edges of the paper to move freely.

How the paper is perceived:
The screws make up a discrete joinery. It is an unconventional way of joining paper that gives a new perspective on the material. The movement of the edges of the sheets feels different depending on the placement of the screw.

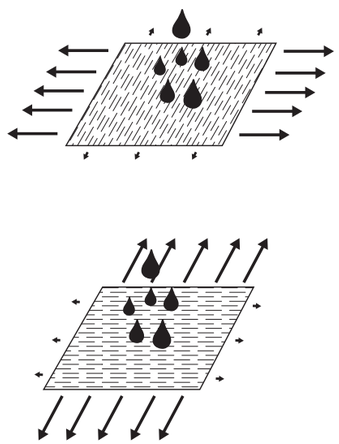
Moisture+Grinding

How the paper performs:
The paper is most worn where it is most wetted and will break more easily where it is not compressed.

How the paper is perceived:
The individual sheets appear more at the sides and less in the middle of the bundle when worn. The surface appears softer and lumpier.

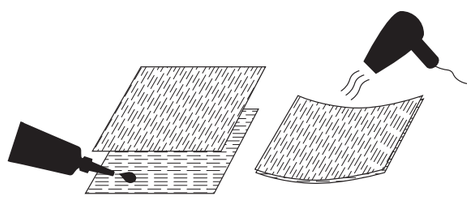
CELLULOSE FIBRE

This is the main component in paper.
The fibre swells when it is wetted.
This affects the thickness of the fibre more than the length.



INDUSTRIALLY MANUFACTURED PAPER

Fibres are mainly oriented in one direction.
Paper swells mainly in one direction when wetted.



LAMINATING

Two industrial paper are wetted and turned in a 90 degrees angle to each other. Than they are laminated with wood glue. The laminate curls up when dried.

Design concept,
Building envelope:

Living laminates

Our second design concept is the living laminates that constitute the building envelope. We choose to work with laminates since it is a way to display the thinness of the sheets and papers reaction to moisture.

Industrial+ Hand made paper

How the paper performs:
The fibre orientation of the industrial paper makes it swell and shrink more than handmade paper. When the laminate dry, the industrial paper shrinks more and the laminate curls. The outdoor wood glue gives a stiff, yet flexible, laminate.

How the paper is perceived:
This paper combination highlights the visual and tactile differences between the irregular handmade and the smoother industrial paper.

130gr + 130gr laminate

300gr + 300gr laminate

200gr + 200gr laminate

130gr+transparent paper laminate

Different grammage

How the paper performs:
The thicker laminates curls more evenly than the thinner. The thin curls more but gets dented and different from time to time. All of them are translucent and the thinner lets more light through.

How the paper is perceived:
The papers formation is more visible in the thinner laminates since they let more light through. The rustling sound of the laminates are different depending on the thickness of the paper.

100x100mm (300gr)

150x200mm (300gr)

300x400mm (300gr)

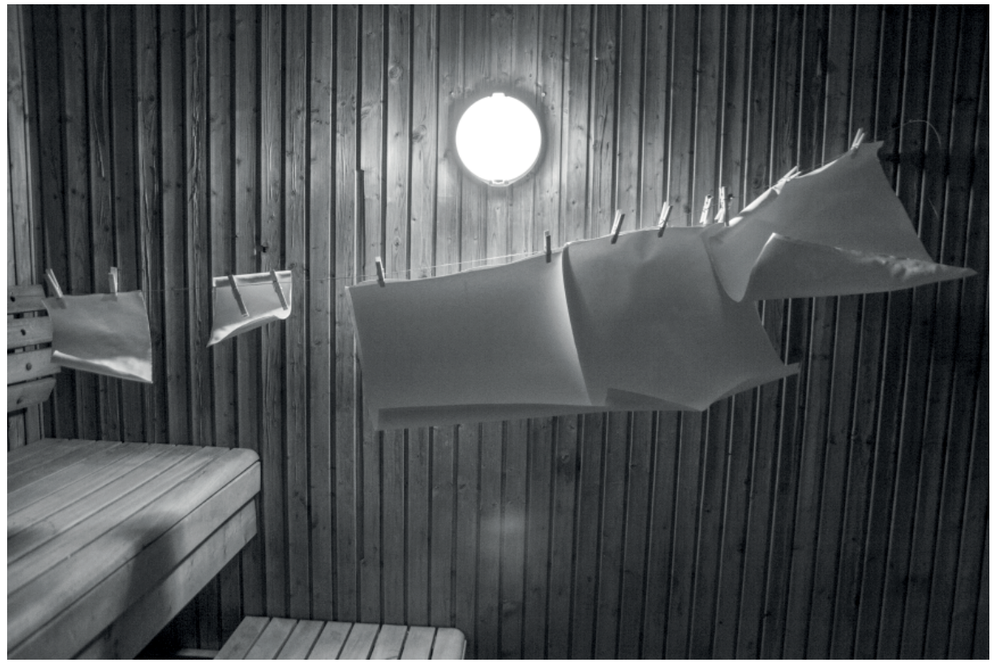
450x450mm (300gr)

700x700mm (300gr)

Scale size

How the paper performs:
The smaller laminates have a proportionally bigger curve than the larger.

How the paper is perceived:
The smaller, more curled up laminates, are perceived as more lively and unruly. The larger, slack laminate is more similar to a regular sheet of paper.



Wet and dry laminates

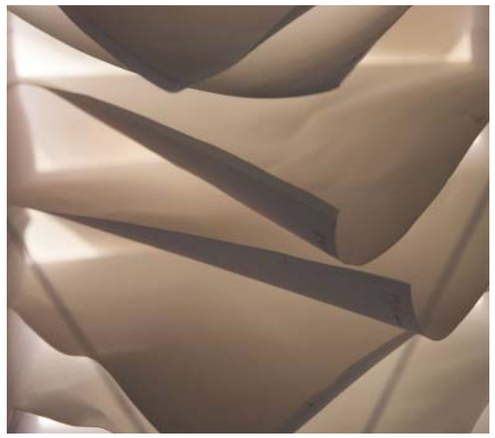
How the paper performs:
All the laminates are possible to wet and dry multiple times without loosing the curly movement.

How the paper is perceived:
The smaller laminates dries faster than the larger ones which make the curly movement possible to catch with the eye.

WET EXTERIOR LAMINATES

DRY EXTERIOR LAMINATES

WET INTERIOR LAMINATES



DRY INTERIOR LAMINATES

Phase two:

Building envelope-Living laminates

Light study

How the paper performs:
When the laminates are wetted they collapse and creates a thin skin that keeps the air from flowing through. As the laminates dry they curl up and let the warm air out.

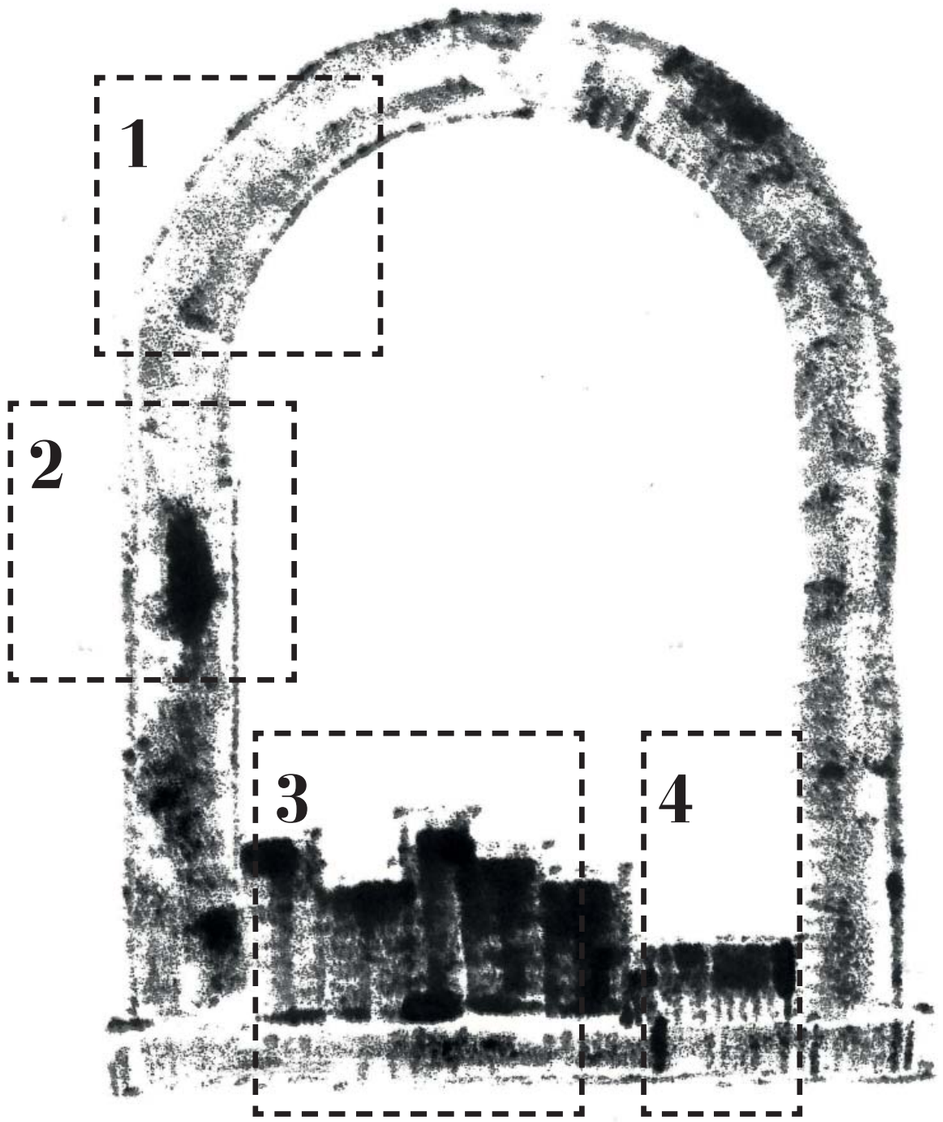
How the paper is perceived:
When the laminates collapse they let less light through and create a darker interior. The overlapping pattern of the laminates is more visible. Curled up laminates will let more light in. They will create a rustling sound if a breeze hits the wall. The overlapping pattern of the laminates is less visible.

One layer insulation

How the paper performs:
The one layer paper garbage sack is not insulating well but keeps the hot air from escaping.

How the paper is perceived:
The formation of the kraft paper is less even than the printing paper and makes up a visually grainy surface, letting some light through.

PHASE 3:
FOUR SAUNA ELEMENTS



Section sketch

Shows the relation between
the four sauna elements.

The prototypes overview

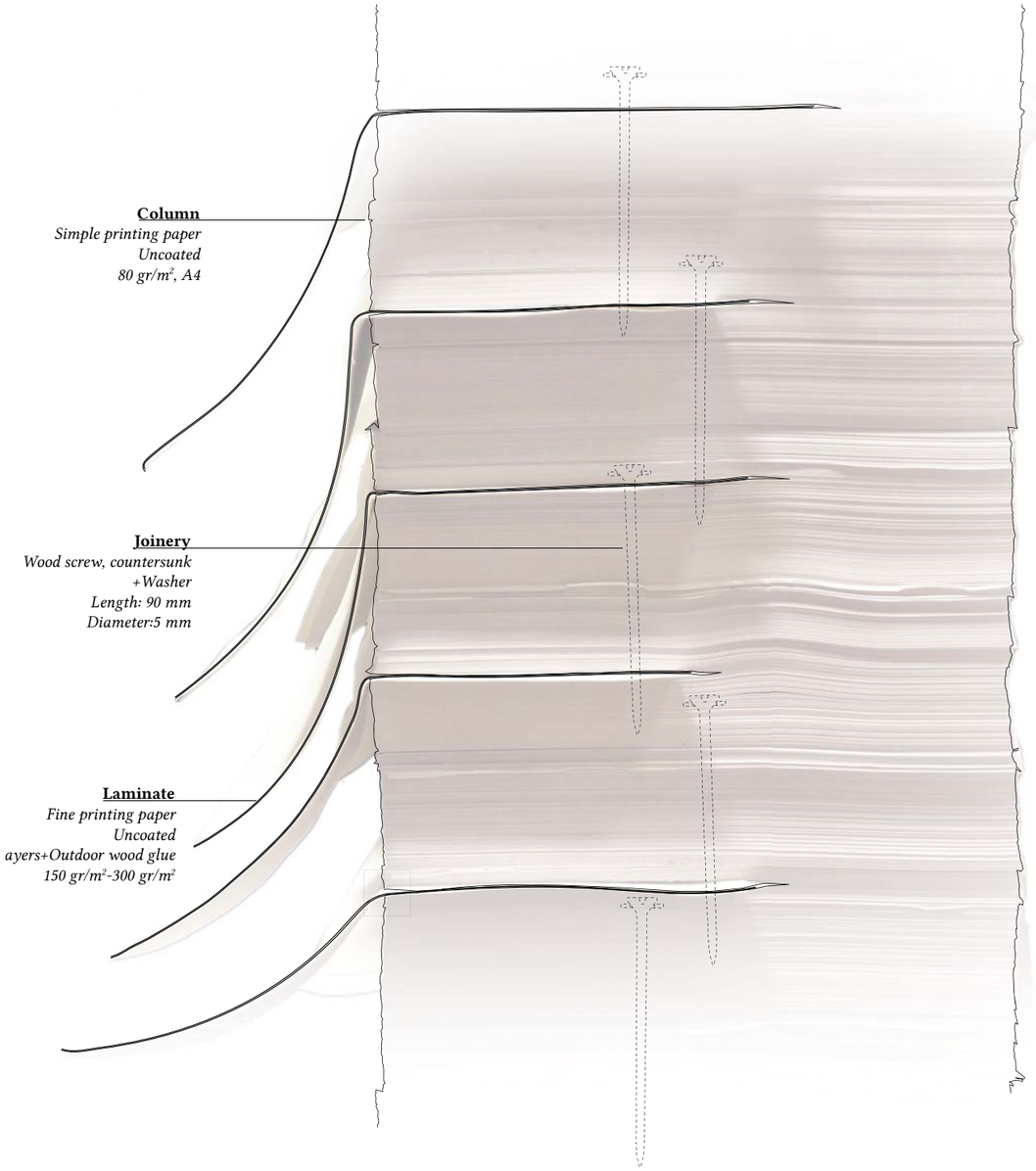
In the third phase we have used the earlier research to inform the design of four papery sauna elements:

1, A vault

2, A laminate wall

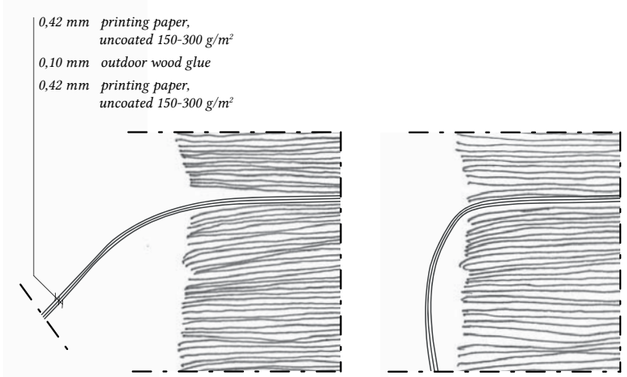
3, A warm seating

4, A springy floor



Detail section 1:2

Phase three:
Four sauna elements

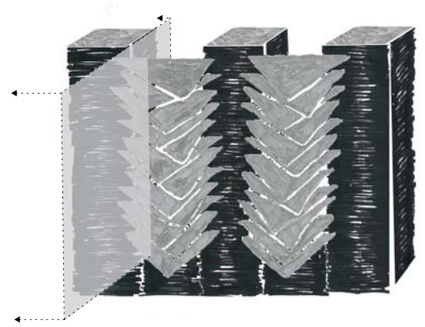


Detail section 2:1

DRY
The built in tension makes the laminate curl and open the wall.

Detail section 2:1

WET
The moisture makes the laminate collapse and enclose the space.

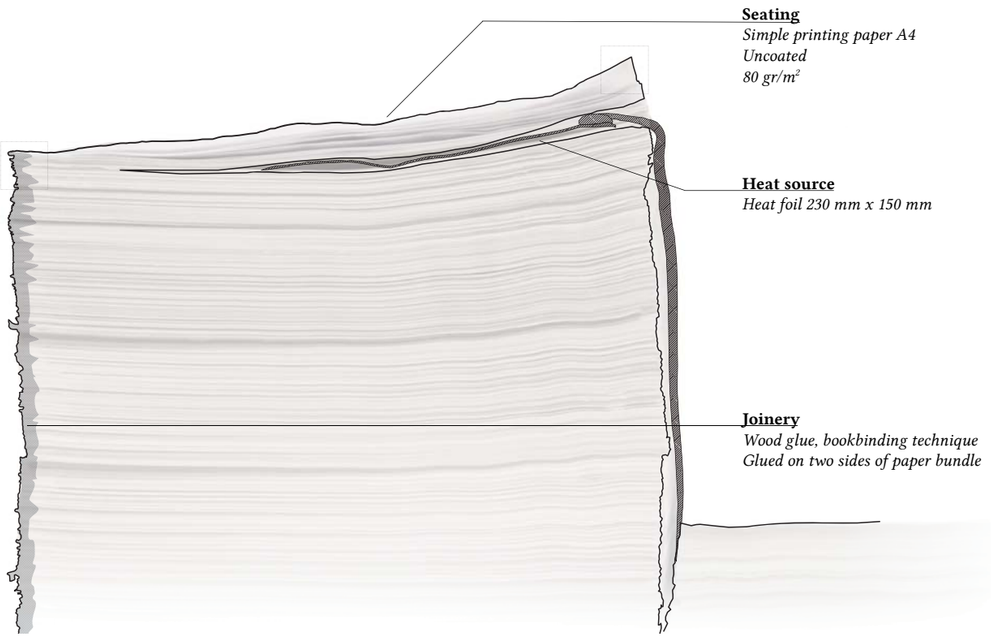


Laminate wall

The laminates in the wall reacts to moisture by collapsing and enclosing the space, keeping the hot air from escaping. When dry, they let the hot air out.

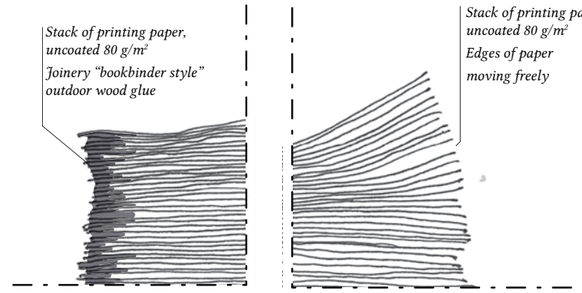
How the paper performs:
The dry laminates are curled up and collapses when wetted. The centrally placed screws of the compressed, solid columns allow the edges of the sheets to move as a response to moisture.

How the paper is perceived:
The contrast between the heavy columns and light laminates showcase the contradictory side of paper. The laminates let diffuse light into the sauna and show an overlapping pattern. When moving the dry laminates make a rustling sound.



Detail section 1:2

Phase three:
Four sauna elements

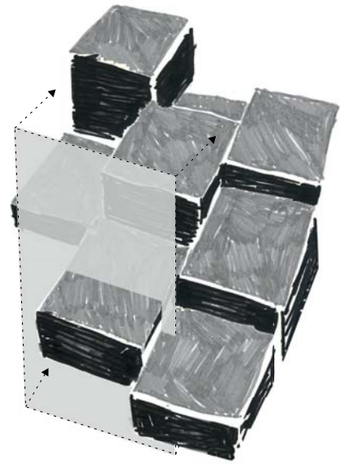


Detail section 2:1

GLUED
The glued side of the stack is fixed.

Detail section 2:1

UNGLUED
The unglued corner of the stack moves freely.

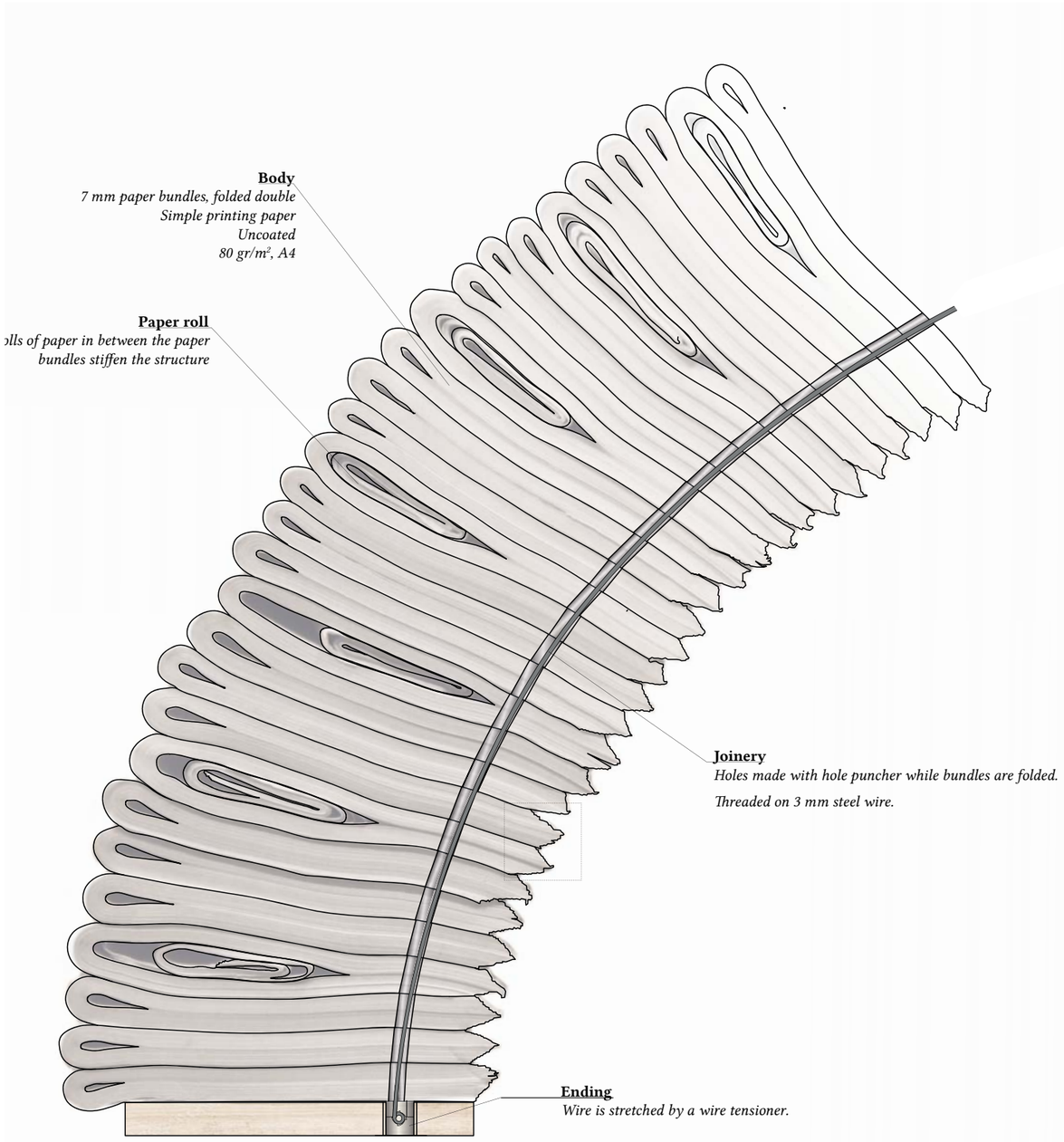


Warm seating

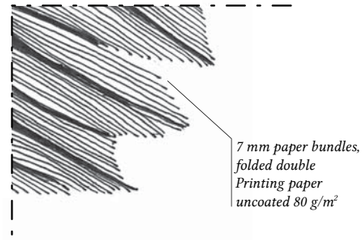
Electrically heated paper stacks become a modular sitting space where the sheets respond to moisture.

How the paper performs:
Gluing the stacks on two sides "bookbinder-style" allows the sheets in one corner to move freely with the moisture and temperature. Paper insulates well and the vertically oriented paper stacks helps us to regulate how deep the heating foil is placed, regulating the surface temperature.

How the paper is perceived:
The smooth surface of the heated paper gives a warm sensation when in contact with the body. The heat enhances the papery smell.

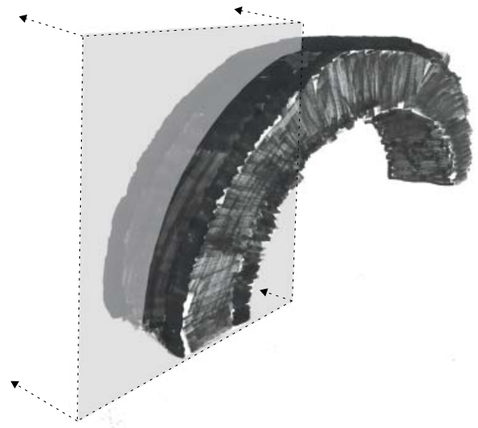


Detail section 1:2



Section detail 2:1

DOWN-FACING SURFACE
The ends of the folded bundles create a pointy surface.

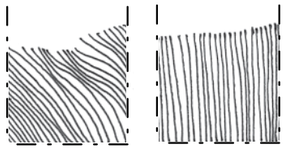


Vault

The span of the paper vault will be the load bearing structure of the roof. As the air humidity rises the papers swell and makes the vault more stable.

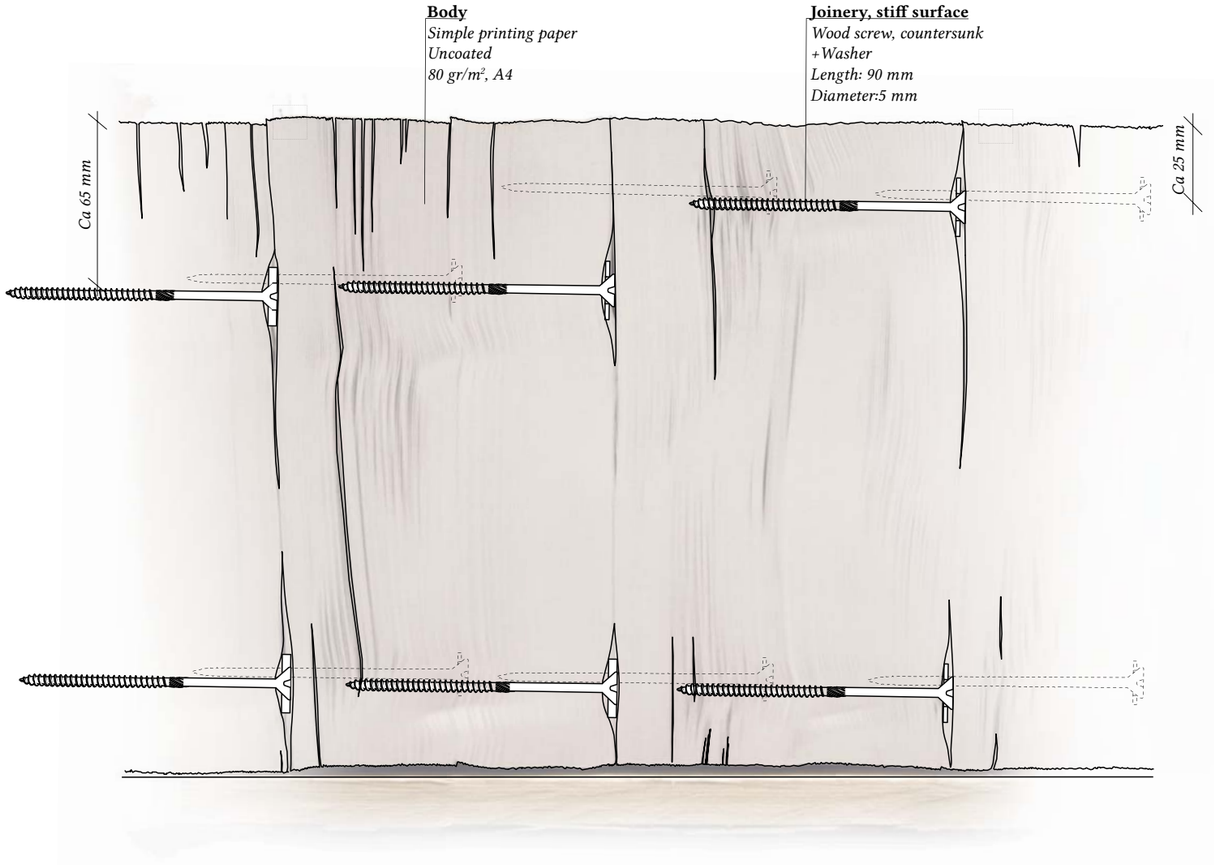
How the paper performs:
*The paper works well in compr*ession. The curve of the arch and the tension can be adjusted by placing more paper rolls into the folded body.

How the paper is perceived:
The vault looks heavy and layered. Folded bundles create a geometrical difference between the faces of the vault which results in a pointy texture on the inner face and a rounded texture on the outer face.

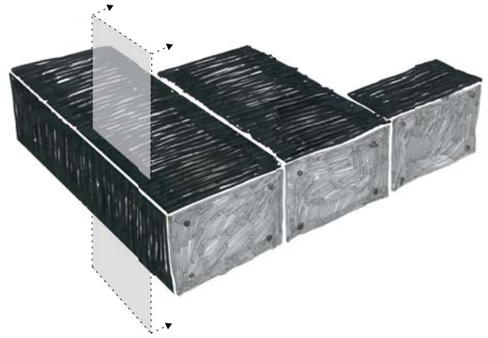


Detail section 2:1

SURFACE
Springy and stiff surface under the pressure of a foot.



Detail section 1:2



Springy floor

Floor made out of vertically standing A4 sheets, joined by screws on different depths.

How the paper performs:
The screws make the floor endure heavier point loads. Where they are closer to the sheets edges the floor is stiffer and gets visible dents. Where the screws are further down they are invisible and the floor is springier.

How the paper is perceived:
The different placement of the screws makes you experience the paper both as a solid and as individual sheets with your feet. The dents created by the screws become an ornamentation of the surface.

Result: Paperness

These prototypes manifest a lot of papery properties that can contribute to a papery experience:

Constructive performance: How paper works in compression and how the built in tension create springiness.

Reactive performance: how paper is affected by moisture, heat, and pressure.

Familiarity: The A-format is used in different ways showcasing possibilities as a modular system.

Visual sensation: How the laminates strain the light and how the sheets can be read as textured solids or individuals.

Tactility: You get to experience both the surface and the edge of the sheets when walking and sitting on it. You also get to feel the heat insulating qualities of the paper.

Smell: The moisture and heat enhances and brings out the papery smell.

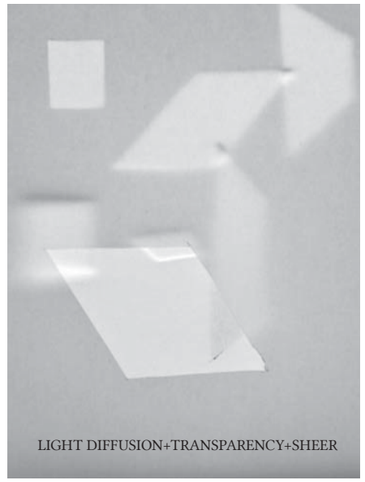
Sound: The paper makes a silent floor while the dry laminates rustle when moved.

PAPERNESS


MATERIAL MEMORY+FRAGILE+UNELASTIC


FLAMMABLE+INSULATION+HEAVY


RUSTLING+FLIMSY+LIVING MATERIAL


LIGHT DIFFUSION+TRANSPARENCY+SHEER


GOOD IN COMPRESSION+MODULAR


INTUITIVE DESIGN+LIGHTNESS+TENSION


SMELL: WARM LAUNDRY ROOM+VANILLA?


SMOOTH SURFACE+ABSORBING+TENSION


SPRINGY+PLASTIC+FOLDABLE


POROUS+SWELLING+LIVING


FIBERY+LAYERED+HEAVY


AFFORDABLE+SHARP EDGES+SPRINGY

- PERFORMANCE
  - CONSTRUCTIVE
    - plastic
      - foldable
      - flimsy
    - good in copression
      - unelastic
    - tension
      - springy
      - material memory
  - REAKTIVE
    - porous
    - absorbing
      - swelling, living
    - fragile
      - stainable, ripable, flammable?
    - temperature insulation
- PERCEPTION
  - APPEARANCE
    - lightness
      - thin sheets
        - layered
        - modular
    - different levels of transparency
      - light diffusion
      - formation
  - TACTILITY
    - dry
      - fibery
    - smooth surface
    - sharp edges
    - springy
  - SOUND
    - rustling
    - silencer
    - “rrrritsch”
  - SMELL
    - warm: laundry room
    - old books: vanilla
  - OTHER VALUES
    - relatable
      - familiar
      - affordable
      - intuitive design
        - crafty
    - contradictory
      - sharp/smooth
      - stiff/soft
      - rough/glossy
      - light/heavy

CONCLUSION

Our findings show that there are unique papery qualities that could provide new ways to design and experience full scale spaces.

The A-formate gives a modular system that can be finely adjusted in one dimension and the plasticity of the paper sheet gives the possibility to hack the modular system. By treating the sheets as plastic building blocks we have been able to create a variation of elements where paperness perform and is perceived differently.

We think that there is space for more bodily experiences in architecture and using unconventional materials can be a good way to investigate this since there are less preconceptions of how the material is used and behaves. Still we have let our preconceptions on how paper work help out to move forward, trying to figure out how papers reaction to humidity, heat and wear could inform the design. We found that paper might not always be as sensitive as we assumed even though our designs might have a shorter life span than conventional materials.

But this thesis is not only about paper. It is also about how to give a new reading of a simple and well recognized product by using it in a new context. We have seen that an unexpected beauty can occur when trying new methods to enhance a materials performance. The ornamented surface of the paper bundles that was created by the screw-joining technique and the pointy down-facing surface of the vault would probably not have been discovered if it wasn't for an urge to test efficient ways to build with paper sheets. These kinds of unpredicted effects will occur when testing and challenging the properties of any material.

Some might argue that the lack of a finished design proposal makes this thesis something different than an architecture project. We claim that this is architecture in a small scale, starting from the details within rather than a site or program. The risk of a proposal stealing the focus from our investigations on paperness made us deliberately leave out drawings of a complete sauna.

During the semester we have developed a three-phase-method in for investigating how paper can be used in full scale architecture, but it can also be used when exploring other kinds of unconventional uses of a well-known material. Key factors are the unconditional research (by meeting experts and making hands-on tests) to inform full scale prototype tests on a specific design. The principles of the method could probably also guide explorations regarding building programs and design proposals.

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