Plastic bags reimagined

Discovering gestures of a recycled material

Master Thesis by Laura Dallamassl

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Matter Space Structure

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Abstract

Plastic bags are the embodiment of wasteful material. After an energy intensive production with crude oil as base substance, the usage is short despite of its longevity. The majority of plastic bags are used one time for an average of 20 minutes. Then they start to become valueless, disappear within the amount of waste and finally threaten our environment. The consequences are to reduce plastic bags or better to ban them. However what about the already produced ones, which are free-floating around or dumped in landfills?

I am curious about abandoned plastic bags, which we are mostly not aware of. This specific plastic material is available in abundance and an integral part of our daily life. However once plastic bags are turned into waste it becomes a pervasive and polluting material. My intention is to first gain an understanding for the planar materiality and secondly discover unintended qualities by simply experimenting with the material. The exploration of recycled plastic bags is a journey of finding interesting gestures and preciousness in an otherwise worthless and unpleasant material.

In the course of the experiments I put the focus on one specific method, which is loosely packed layers of plastic bag membranes that are simply kept together with sticks. Thus an original flat material is turned into a three-dimensional system, that comes along with visual, tactile and auditive qualities. I will explore the material's gesture through different light situations and in the following develop a possible architectural application.

Hence this thesis is an investigation of recycled plastic bags - a material that is traditionally not associated with architecture. I am following my curiosity of addressing our negative perception with waste material, exploring its possibilities and eventually bringing it back to a more worthy state. The purpose is to join the conversation of material gestures in order to look freely at the material's experience and create unexpected expressions.

Key words
Waste, Plastic, Material Gestures, Light, Experience

Thesis questions
What are material gestures of recycled plastic bags?
How can light influence the experience of matter?

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1.0 Introduction

Discourse

The subject to this thesis grew upon the thought how the increasing problem of wasted material can be addressed through an architectural attempt. Waste is matter, that is simply out of use and on top of that its reputation is unpleasant. Therefore especially designers, who are directly working with materials, are interested in the resource waste trying to reintegrate it and to upgrade the image of discarded material. Since architects are responsible in choosing building materials, it is also crucial for them entering this discussion.

I am particularly interested in addressing our negative perception with waste material and to explore its possibilities and eventually bringing it back to a more worthy state. Hereby my main concern lies in plastics - one of the most pervasive and polluting material of our modern life. Once plastic is turned into waste it becomes a hazardous material and we lose control over it. Since it takes long time to biodegrade, it is a very durable and long existing material. Through the change of time it degrades into tiny particles and finds its way into oceans, being a threat for aquatic life and in the further course getting into our food chain and in the human organism. (Harvey and Watts, 2018)

Discarded plastics have a fascinating side as well, that I want to illustrate with the photograph, that shows an orange balloon left behind in nature. Due to its colour and materiality this piece of plastic sticks out of the natural environment being almost a jewel in the grass. With my thesis I want to address this double-edged nature of plastics, which makes it a very interesting and unique material to work with.

During the process of my thesis I visited the exhibition "Wasteland" (Lendager Group, 2018), which gave me insights in the current movement of recycling material among the discipline of architecture. One claim was to keep the material's identity as well as possible in order to save energy and to not loose its value. Dirk Hebel states that "waste should be treated as asset and as opportunity for the architectural production because the world is running out of resources" (Building from Waste, 2014). However I also got inspired how reusing material can likewise mean creating beautiful matter.

A patina of a material created by traces of time has already inherent qualities. Plus it is also emotional relations we have with materials, that can be extended or renewed. For instance plastic bags that is an everyday object. What happens if it becomes part of architecture?

Since there is a vast variety of plastic waste, I decided to focus on one specific kind, which is plastic bags - a material that comes from outside architecture. For me this material is the embodiment of waste since the majority of plastic bags are used only one time for an average of 20 minutes. Even though it is very resilient and can take up to 400 years to biodegrade. During the preparatory course I could lay the foundation for this specific waste material, how it behaves, how it can be recycled and transformed. My intention is to clearly not foster further production of plastic bags. Thus with my work I am trying to understand recycled plastic bags as a material and discover gestures and opportunities that change the perspective in how we normally look at it into something that can be eventually interesting, exciting or even precious.

The thesis is a material-based work of research and the method is driven by materiality, which means materiality informs the whole process. By doing material experiments I develop an understanding for recycled plastic bags and create an archive of various material expressions. By taking photographs of those creations I reflect on them and narrow down the methods in order to take a closer focus on one specific. Since I want to bring the created knowledge to an architectural context, I will test one possible application. However my main objective is to find methods to revalue the notion of recycled plastic bags.

***"Seeing beauty and usefulness in recycled resources paves the way for a whole new world of materials and a new aesthetic expression in architecture."** (Exhibition Wasteland, 2018)*

Artificial treasure

Target material

Main question & objective

The purpose of my thesis is simply exploring discarded material, understanding its behaviour plus finding material and spatial expressions from an architectural point of view. Since architects have the responsibility for material selection, reusing or recycling waste material is part of the current discussion. I am especially interested in redefining our negative attitude towards waste materials, that discusses the paradox existence of plastics in particular.

What are material gestures of plastic bags?
How can light influence the experience of matter?

My aim is to show the opportunity of recycled plastic bags that cannot only be integrated in architectural production but likewise create an atmospheric feature. I argue that recyclable products often only exist for the sake of reintegrating material in the circular economy. However, I want to investigate the potential of recycled plastic bags, where the intention of "just" reusing is equal to the intention of creating beautiful matter.

In the course of the process I narrow down the material experiments and focus on one specific. Thereafter I will investigate the chosen method, test one possible architectural application and try to raise the materials value by means of light.

Recycled matter

Recovering raw materials from waste products is a growing field of interest especially among designers. Regarding paper and glass the recycling rates in central Europe are over 80%. Concerning plastics 60% are getting recycled. This movement is increasing not only due to optimised waste management technologies and rising crude oil prices but also due to growing awareness of environmental issues. The common ground is that this conversation addresses the value of materials in our society. "Reusing materials not only saves resources, but also significantly lowers the energy required for material production." (Peters, 2014)

There is undoubtedly a current trend in reusing plastics in particular, which in turn inspires many creative thinkers. It aroused from the concern over environmental issues. In addition the vast amount of availability, its versatility and the durability of the material makes it even more popular. Bob Vos and Alessandro Iadarola, founders of Polimeer, state: "In most cases, plastic can be found on the streets or you can partner with businesses that like to donate their leftovers for free. This abundance of plastic in the environment creates an opportunity for young designers to start thinking." (Frearson, 2018) Therefore plastic is currently an always present waste material, which furthermore is easily to work with.

The European architecture students assembly EASA state that they do not believe in trash. Hence their mission is to dig into new dimensions of usefulness to find value, meaning and potential in the endless amounts of waste referring to all kinds of trash: wasted material, abandoned space and wasted time. They challenge architects to reconsider their role and attitude in the hyper produced reality, to embrace the existing and to create continuity, where the world needs to build upon itself from its own waste, its own mistakes and its lessons. Instead of constantly producing the new, it needs to be recreated, reborn and re-imagined. (EASA, 2017)

Plastic bales, Veolia

Ocean pollution, Rich Carey ©

Plastic pollution

Since the 1950s synthetic materials are a grounded element in our lifestyle symbolising technical progress and wealth. However towards the end of the 20th century criticism on polymers increased due to a change of environmental awareness. Plastics especially regarding plastic bags have a large impact on environmental issues such as water pollution and as a consequence negative effects on aquatic wildlife. The so called “plastic soup“, which consists of small pieces of plastic is consumed by maritime organisms and can alter the biological composition of them and in the further course entering the human organism. (Greentumble, 2018) Plastics are clearly loosing its importance and thus the material will not have a flourishing future. Nevertheless polymers are all around the world and cannot be neglected since the life span will continue. Therefore strategies of how to reintegrate plastic waste into a circular economy and how to keep its negative impact on our environment as small as possible, have to be developed.

Plastic stones

Duality of plastics

Plastics can be both - beautiful and ugly at the same time. This double-sidedness makes it not only interesting to work with but also controversial. In the following I will try to elaborate on this dual aspect of plastics regarding its use and its appearance.

Use of plastics

Plastic is artificial produced matter with extraordinary capabilities such as strength, versatility and durability, which makes it a valuable material. Thus plastics are responsible for the progress of the modern era and are therefore a technological 'Wundermaterial'. However plastics have likewise a dark side, that is concerning their high ecological impact. In that sense it is less valuable, because fossil materials and a big amount of energy are needed for its production. In the following plastic is often treated without care since it is a mass-produced and therefore cheap material that is available in abundance. After a short time of use, plastics are turned into unwanted material, need hundreds of years to biodegrade and destroy the natural ecosystem.
Therefore plastics have this aspect of duality already concerning their use, where the material starts as a good performing one and ends as a bad performing one. Generally speaking materials, that have a reason to exist or accomplish a purpose are more likely considered as beautiful. However materials, that turn into unwanted material or hazardous trash are usually considered as ugly.

Appearance of plastics

Plastics can come in all shapes, colours and textures. However most commonly plastics are having smooth and glossy surfaces. This characteristic appearance also developed the idiom that materials "look artificial". Thus it creates the opposite to natural existing matter. Plastics are almost looking too perfect, because of their spotless appearance and therefore being a fascination by themselves. However this artificiality, where the material is detached from nature and humans are not familiar with, can also create refusal or disgust. In addition disgust often comes along with formlessness, randomness or chaos. For instance Gaetano Pesces body of work is centred around pouring, melting or dropping plastics, that result in arbitrary shapes and forms. Thereby he questions the perception of beauty and he states 'that we want something human in design and the only way is to introduce the badly done into things, that gives objects a soul.' (Wiles and Bates, 2019)
To conclude the look of synthetic materials is dual, since fascination and ugliness lie close to each other. Plus it is a matter of our current aesthetic values, that define what kind of colours, forms or materials are regarded as beautiful. Due to increasing environmental awareness plastics have lately turned into material that gets perceived as rather ugly than beautiful.

Method

This thesis is research-based and deals with the material of recycled plastic bags. The work is process driven, since the emphasis lies on testing the material, transforming the material and creating new gestures, that is not aiming at producing one final product.

The method I have chosen is driven by materiality, which means that materiality informs the whole process and all further steps are consequential decisions. By doing iterations of material experiments I develop an understanding for recycled plastic bags and create an archive of various material expressions. By taking photographs of the outcomes I reflect on them and narrow down the methods in order to take a closer look at one specific. Hereby the camera acts as an important tool for converting physical models into images and by choosing specific details and angles of view I want to address certain issues.

Delimitations

My intention is not to solve the issue of collecting and cleaning abandoned plastic bags as I want to put my focus on the materiality itself and create an archive of material gestures. Hence I consider this thesis as an exploratory work, that is characterised by the process itself, where the design project is not the conclusion, instead it creates one possible answer.

The basic principle is to use recycled plastic bags since I do not want to foster further production of them. Therefore the raw material is mainly recycled plastic bags, which I received from the company Veolia. However I do not totally exclude new plastic bags, that helped me in the beginning of the process to focus on the material itself. As a consequence of my preparatory investigations I will work with the method of fused plastic bags, that creates a more resilient and stiff material. The so-called "plastic bag membrane" is the starting material for all experiments.

When changing the constitution of the material, I will treat the material exclusively with heat and not with any chemical medium. In addition I do not exclude coloured or labelled plastic bags, instead I handle this aspect as design opportunity.

2.0 Background

Plastics

History of plastics

The term "plastic" derives from the Greek word "plastikos", which means fit for moulding. Hence plastic is a material, that can be cast, pressed or extruded into various shapes. Plastic is clearly the material of the modernistic world, which has significantly changed and shaped our way of living. It is the reflection of the industrial acceleration, democratic consumerism and mass disposability of the 20th century. According to Roland Barthe plastic is "the first magical matter that consents to be prosaic". In 1907 the first synthetic mass-produced plastic was developed by the Belgian chemist Leo Baekeland, called Bakelite. (Myerson, 1998) Since then a wide range of plastics has been created and its use reaches from packaging to healthcare to buildings. It became a clearly indispensable material, although it is very young in its existence. (PlasticsEurope)

How plastics are made

For the production of plastics natural materials such as cellulose, coal, natural gas, salt and crude oil are needed, which are processed through polymerisation or polycondensation. However crude oil is a complex mixture of thousands components and needs to be prepared before using. In refineries the oil gets filtered in various fractions and the substance "naphtha" is needed in order to produce plastics. The three main groups are thermoplastics, thermosets and elastomer. Thermoplastics consists of molecules, which are lined up like a chain and it softens on heating and hardens on cooling. This process is reversible and therefore thermoplastics are mechanically recyclable. Thermosets however have molecules, that are connected in a three-dimensional network and they do not soften again once they have been moulded. As a result they are very hard and robust. I only work with thermoplastics, that in turn have many sub-categories. However I am focusing on polyethylene, which is the main compnent of plastic bags. (PlasticsEurope)

How plastic bags are made

Polyethylene, the main ingredient of plastic bags, is sensitive to heat and becomes liquid at a melting point between 110-130°C. The heat deflection temperature is around 85°C. In the manufacturing process of plastic bags, polyethylene films get extruded, stretched and cooled down. After that the actual plastic bag can be produced. (Greentumble) Therefore plastic bags are made out of a thin film consisting either of HDPE or LDPE. High density polyethylene (HDPE) is based on chains that branch out very little and it is used for packaging, bottles and light disposable plastic bags. Whereas low density polyethylene (LDPE) with molecule chains that branch out a lot is commonly used to create normal, robust shopping bags. (Lacoma, 2018)

HDPE

LDPE

Preparatory course

In my previous semester I investigated in waste material with an architectural approach. My motivation was to turn an unwanted and disposed material into useful and beautiful matter, which can be integrated in our built environment. I decided to focus on one specific material - it became plastic bags. After trying to understand the behaviour of the material, I started to do experiments, which included additional materials and tools. Among other findings I learned how to weld together planar plastic bags and how to transform them by means of heat and pressure into three dimensional elements. For this method I created CNC cut foam models, which were the underlying form for the vacuum transforming machine. After the sheet gets heated, the vacuum of the machine presses the form and the material together. As a result the plastic membrane gets a three dimensional imprint, which keeps its shape also after cooling down. Once this process was smooth, I created iterations of textures and I could recognise a pattern how the self stability of the elements got influenced by it. In the final step I reflected upon the created material and summarised the findings in a library of characteristics, which became important parameters for my thesis work.

 # Movement

Physical impact and wind forces are deforming the material because of its low weight and thinness. However once the forces are removed, the artificial skin gets back to its original shape. This process introduces movement to the material, which therefore changes the shape and the appearance during time.

 # Translucency

The plastic membrane is a translucent material and depending on the amount of layers it can reach from transparent to opaque. Due to the irregularities of the texture the light gets not transmitted smoothly and also the depth of the shape is influencing the light.

 # Hollowness

The vacuum transformed material appears almost like a solid object but in reality it is hollow and only the section shows the real nature. If forces are affecting the material, the hollow characteristic gets revealed as well. The hollowness gives an impression of lightness and movement. It creates also the possibility for being filled with another material, for instance water, concrete or light.

 # Softness

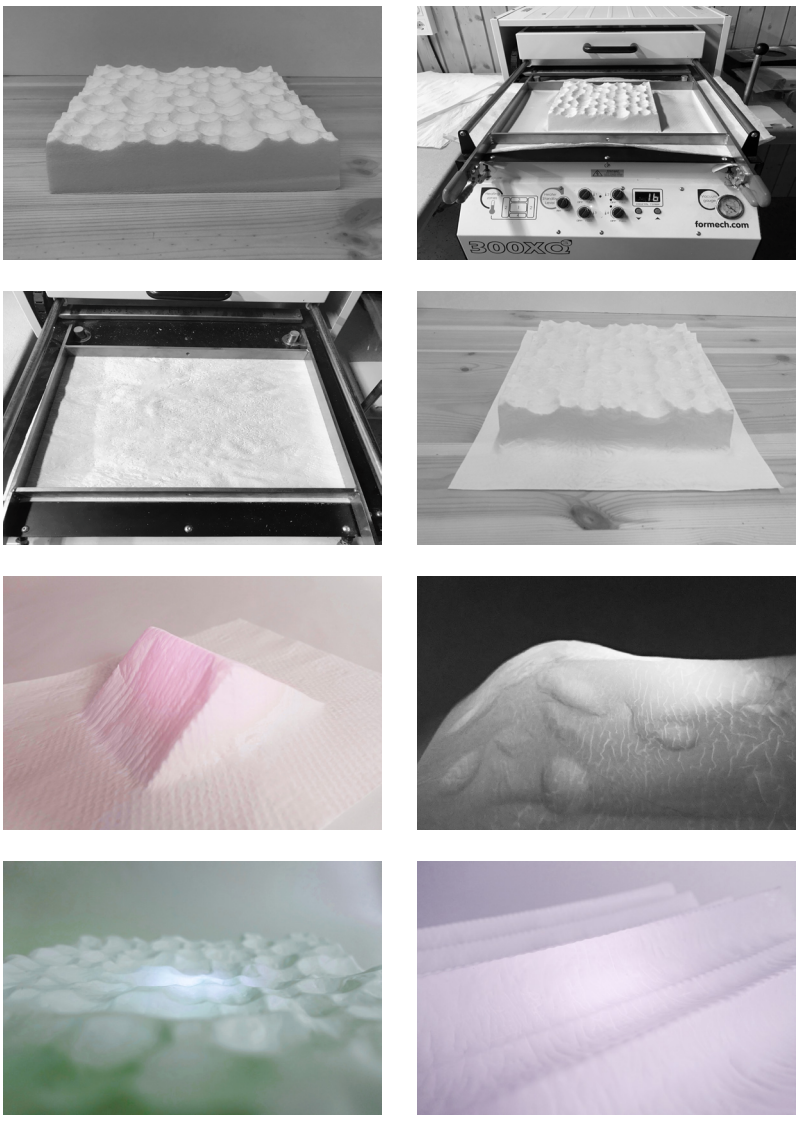
The material appears soft due to its thinness but also its smooth texture. The edges are not sharp and the material is flexible, when exposed to slight exterior influences. It has similarities to paper but with increased durability.

 # Lightness

Since the material is very thin and light, it is not capable to carry weight. However it can cover, protect or simply work as a spatial component. The material delivers a feeling of lightness and depending on the angle of view it appears almost solid. In an architectural context it has to be combined with load bearing components.

 # Plasticity

The original product, a plastic bag is still recognisable but only if you are informed about the underlying process. However the geometry has changed - from a single layered plastic bag to a multi layered sheet. After the vacuum transformation the flat material deforms even more to a three dimensional object. The plastic membrane keeps its shape after removing the mould while being soft and floppy.

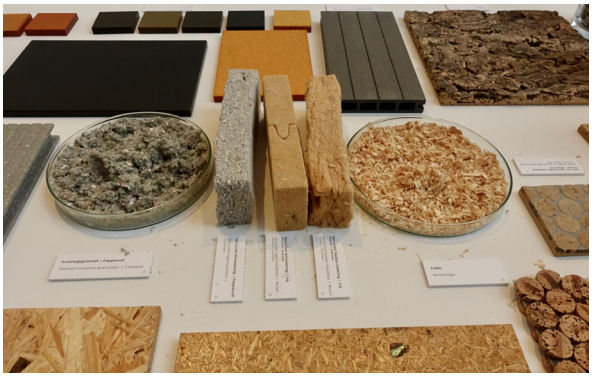


Vacuum transformation and surface studies

Inspiration

In the course of my preparatory work I visited the exhibition “Wasteland“, located in Värnamo, realised by the Danish architecture firm Lendager Group. The title “From waste to architecture“ was the red thread through the exhibition with focus on waste materials itself, which were separated into themes such as wood, glass, steel, concrete, brick and plastic. Every station was accompanied by an architectural example of how to reuse those materials in our built environment. The presented projects were mostly situated in Denmark.

I appreciated the tactile experience of the exhibition, since material samples and building components were demonstrated and thus created a better sense for recycled materials. However the emphasis laid rather on the technical aspects of the materials and less on the atmospheric qualities. Therefore questions as how those recycled and reinvented materials influence space were kept open and triggered my curiosity. Nevertheless the exhibition “Wasteland“ provided me with a good overview on the current recycling movement in architecture, where waste is no longer residual matter but instead an important untapped resource. Plus “Wasteland“ pointed out that Scandinavian countries are pioneers in that field.



Wasteland, Värnamo

Veolia site visit

Veolia Environment S.A, branded as Veolia, is an international company with operations on water management, waste management and energy services. The concern is an innovative example regarding the management of solid or liquid non-hazardous or hazardous waste. Veolia is involved in the entire waste life cycle from collection to final treatment with the aim of recovering resources. The company calls itself as a stakeholder of the circular economy and thus creating methods to increase the rate of waste recycling and conversion into matter or energy. (Veolia, 2019)

After several attempts trying to contact recycling companies with a specialisation on plastics that in addition are situated in the area of Gothenburg, I finally stumbled upon Veolia Recycling Solutions Sweden. The employees were really accommodating and offered me to visit their site based in Hisings Backa. I was very lucky getting a personal tour through the facility. Veolia Hisings Backa are focusing on waste such as plastics and cartons, that they receive from garbage companies. After separating the different kinds of plastics Viola harnesses the material, which is mainly done by an automated operating procedure. After the material is pressed and shaped into bales, the material can be stored and transported more easily. Then the resource gets sold to further companies, where they either create new products or energy. Veolia is basically an in-between stop for waste, creating an important base for the recycling process.

As a conclusion the site visit of Veolia gave me not only interesting insights in waste management but also valuable raw material for my project. I received plastic bags, which were unused but still intact. Therefore I did not have to consider cleaning the material. I realised, that this kind of material is very rare and hardly available. So in order to use this resource in a larger context a method is needed, where non broken plastic bags are transformed to their initial state without being dirty or contaminated.

Veolia, Hisings Backa

Raw material

The main idea of my master thesis is based on using waste as material for architectural production. In the beginning I was using recycled plastic bags, which I collected by myself. Then I received a huge amount of new plastic bags in order to do the experiments. This was a contradictory move, since I did not use recycled material anymore. Once I realised that, it was hard to see the purpose of the project, since I clearly do not want to support the production of new plastic bags. Using recycled matter is the starting point and likewise the foundation of the project, therefore it was important to clarify this issue.

However solving this unreliable part of my project was a difficult endeavour because it is almost impossible getting old plastic bags, which are not directly from the garbage bin. Thus I got in contact with several companies for receiving old plastic bags, that I can use for my further experiments. Most of the answers were not helpful because it was either unclear who is in charge of old plastic bags or the firms simply did not have any interest. But after several attempts I finally got a positive response from the company Veolia. They were willingly to show me their company and to provide me with raw material - old plastic bags, that are neither damaged nor dirty.

Instead hiding this struggle finding used plastic bags, I want to address this within my master thesis. First and foremost it shows the problem of the current waste situation especially concerning plastics. There exists a vast amount of plastic species but there is actually no place where you can get them sorted and cleaned in a good condition. Recycling companies are transforming plastic bags (to handle and store them in a more efficient way) either into bales or they granulate the material. So the plastic bag gets down-cycled, melted and its initial state gets lost. Even though the test materials for my project are not continuously recycled matter, I am aware of this problem. I got confronted with the issue of free floating plastic bags, that are mixed together with other plastic species and it is almost impossible getting them separated. Hence a change in recycling methods is needed in order to handle and prepare the different amounts of plastic waste.

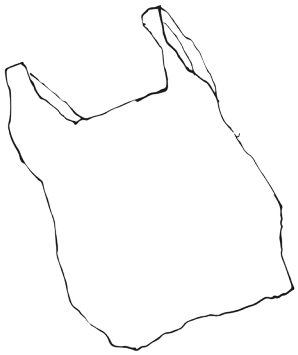
Wasted plastic bags

Plastic bag membranes

During the preparatory course I developed the technique of fusing together several layers of plastic bags, which increases the durability and stiffness of the material. The plastic membrane is more easily to work with since it is not as floppy as a single layered plastic bag. In addition the heating process creates a texture consisting of irregularities, bubbles and wrinkles, that add a specific character to an otherwise flat and smooth material. In the following the process of creating plastic bag membranes will be explained.

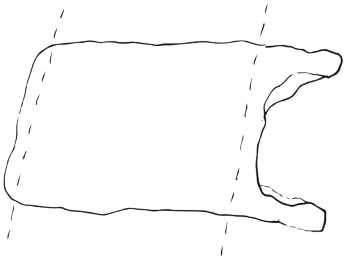
First it is necessary to unfold the plastic bags on a flat surface in order to cut handles and welded edges away. Then several layers can be layered on each other. For the experiments I mainly used 4 layers and if more thickness and strength is needed, the number can be increased. Beginning with one side the iron should slide smoothly over the plastic sheets, which are placed in between baking paper in order to protect the iron from sticking to the material. This is done two times and then the fused plastic is turned around. The back of the plastic is treated in the same manner and after that the membrane is finally produced.

The plastic bag membrane is still flexible and thin but with increased strength. Since a plastic bag has size limitations, approximately 40 x 50 cm after fusing, another heat process is needed in order to create bigger sheets. This can be done by welding the material together, like sewing fabric, this time in the horizontal direction. (I used a soldering iron for this method.) The general appearance of the material is a non-smooth surface with a vivid and random pattern, that reminds a bit of paper. Plus the material is slightly translucent changing with the amount of layers.



1 Recycled plastic bags

The raw material is either HDPE or LDPE plastic bags, which get collected and folded to the initial shape of a bag. The bags should be preferable clean and without bigger damages. Since I prefer a mix of colours, I do not need to sort them.

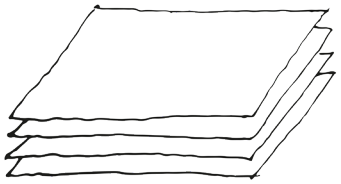


2 Cutting plastic bags

Due to the geometry of plastic bags, it is necessary to cut the handles and the bottom part away. Then two rectangular surfaces are created, that hold together at the sides. The plastic bag material is now flat and ready to process further.

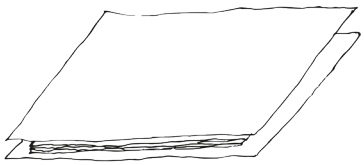
3 Layering

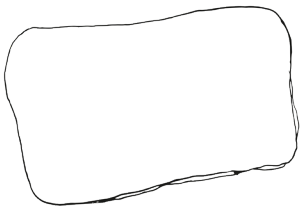
Since the aim is to strengthen the material, it is necessary to layer several plastic bags. I mostly work with layers of 4 but depending on the purpose (increased strength) more can be added. The scale of the material plays also a significant role in deciding on the amount of layers.



4 Fusing

At this stage heat comes in for the first time. Before starting, the layers of plastic bags need to be placed on each other and between baking paper. Then the fusing process can start - a flat iron with heat between 180-200°C combines the layers of plastic bags. It is necessary to have the right speed and pressure in order to not melt it too much or too less.





5 Plastic bag membranes

The end result is a more sturdy sheet of recycled plastic bags consisting of four layers or more. It is a plastic membrane with significant traces of the heating process and it has a certain degree of translucency. The shape of the sheet is more roundish than before and by touching the material a sense of softness is generated.

Anne Holtrop

Anne Holtrop is one of my main reference throughout the phase of experimenting with the material. Since in his studio materiality and the act of making are closely connected, it is an inspirational approach for my investigations. Anne Holtrop is dedicated to work with particular materials and finding its unique gestures. He states, that in his studio the focus lies on exploring gestures of making in relation to a material, where the reality and meaning of the work is the material itself, the form and the act of creating it. This approach produces architecture that does not reference or represent something, neither is it an abstraction, but it simply represents existence as a physical reality. (Atelier Anne Holtrop, 2018) For Holtrop the truth of the material lies not in its refined state but in the impure, worn and lopsided condition. For instance rust is the fundamental property of steel and by avoiding this fact, it detaches us from the primary process and the fully understanding.

Holtrop speaks about his work of "possible architecture", where he often starts with a material or form that comes from outside architecture. Plus he tries to look freely at material gestures and forms and let them be architecture while letting the work be interpretable. His work consists mostly of single material architecture that is free from functions, programme and time scale. Entering his created buildings can be compared to entering a physical model or an enormous installation, where one gets immersed in pure materiality.

Anne Holtrop states that he likes a certain abstraction in materials, simplicity and clarity and that the programme gets introduced somewhere during the process. He explains: "I think it's fine if the programme doesn't fit perfectly. What's essential for me is that my architecture remains open to interpretation; the built result should offer the user space to interpret the work on their own." (Archined, 2016)

Murad boutique hotel

Shaikh ebrahim center

Batara pavilion

3.0 Experiments

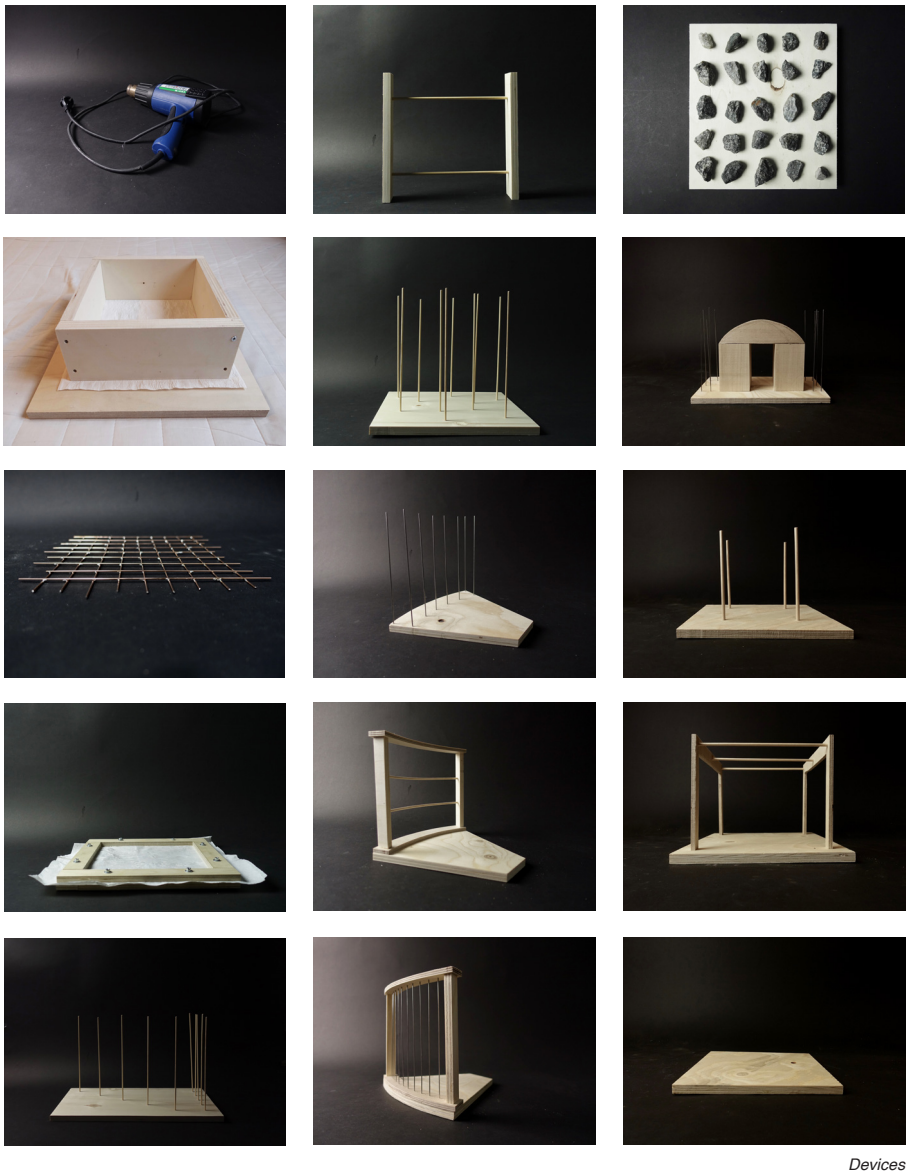
Introduction to material experiments

My intention with doing material experiments was to find different material expressions and ways how to make use of plastic bags, either in an active, passive or hybrid manner. I did not focus on one specific technique how to treat and transform the material because I wanted to foster variety in an experimental way. However I decided to use heat as the main medium to change the constitution of plastics.

Before starting with the experiments I developed simple devices. They can be seen as structures, that tame the material or create a skeleton in order to attach the membrane. They are supporting the qualities of the material or changing the original state and therefore being a reaction to the materials' behaviour. I was trying to bring the devices in the background and letting the material speak. However the structures are needed in order to bring the material in shape or in place.

After conducting the tests I reflected upon the outcome by means of evaluation criteria. It helps to get a quick overview of the tested material and make the results comparable to each other.

1 Type of plastic bag
2 Appearance
3 Thickness
4 Method
5 Tools
6 Durability 1(low)- 5(high)
7 Space defining 1(low)-5 (high)



Devices

Experiment I

The first experiment has a rather experimental approach in order to explore the variety of the material. Five themes, translucency, movement, colour, material and texture, that rely on previous investigations create the only boundary conditions. The experiments made clear that the material does not need to have a functional purpose, instead it can have only visual, tactile, or atmospheric expressions. I recognise three stages of working with the material, that is either in an active, hybrid and passive manner. Plus depending on the amount of heating time the material has different appearances. The texture can be smooth, wobbly or porous (only to mention a few of them). Once the material gets heated it is important to act fast, since the material does not store heat and the cooling down process is quickly. Another aspect of working with plastic bag membranes is imprecision, because of difficulties using heat on a constant level. However I think this introduces a unique and handmade feeling to the material, which is an interesting facet.

Collection I

Translucency and light

Translucency is one of the main characteristics of the material. It can be varied by different kind of thickness's, stacking distances and layers of the material. Light is an important factor, which can enhance translucency. There can be either an internal or an external light source, illuminating the material from different sides.

My starting point is always four layers of fused plastic sheets. First I tested translucency with a parallel arrangement of vertical plastic bag membranes. The distance between the layers is 1 cm and the planes have different sizes in order to show single sheets and the layered sheets. I realised that translucency with four layers is rather low and it is depending on the light source and the distance of the object to the plastic. When my hand is touching the material on the backside, it shines through. However if it is not touching the surface, the material seems to be rather opaque. With this test I could also develop the process of welding plastic membranes together for creating a pocket in order to attach it to the wooden sticks.

 # 1.1

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: thin, fragile and wobbly
3. Thickness: 0,5 mm
4. Method: heat, fused plastic bags
5. Tools: wooden sticks and plate
6. Durability: 1
7. Space defining: 5

 # 1.1

Movement

The characteristic of movement is obvious, since the plastic material is thin, flexible and therefore very sensitive with wind and other forces. I recognise that there is a static and non static movement. So movement can be an imprint or a gesture in the material itself (like a frozen moment) or it can be an actual movement influenced by outer conditions.

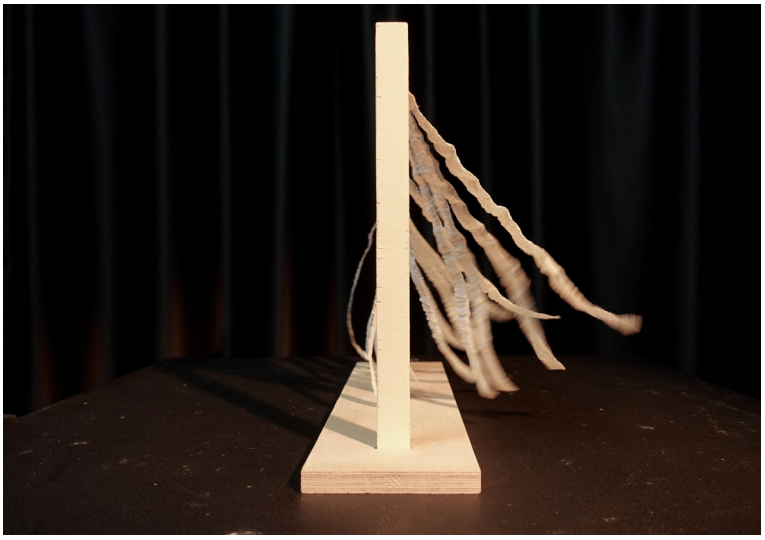
I did two tests with active movement. The first one is a sheet of plastic membrane, which is cut into fringes and it needs only slight influences in order to get the elements in motion. The second test is similar when it comes to the attachment on one side but here the elements are cut in squares and not connected together. However I feel both tests are a bit one dimensional and fragile. Regarding the way of attachment, the horizontal helping structure, where the material falls in the direction of gravity works better than the vertical one (as I did it with the transparency tests).

 # 1.2

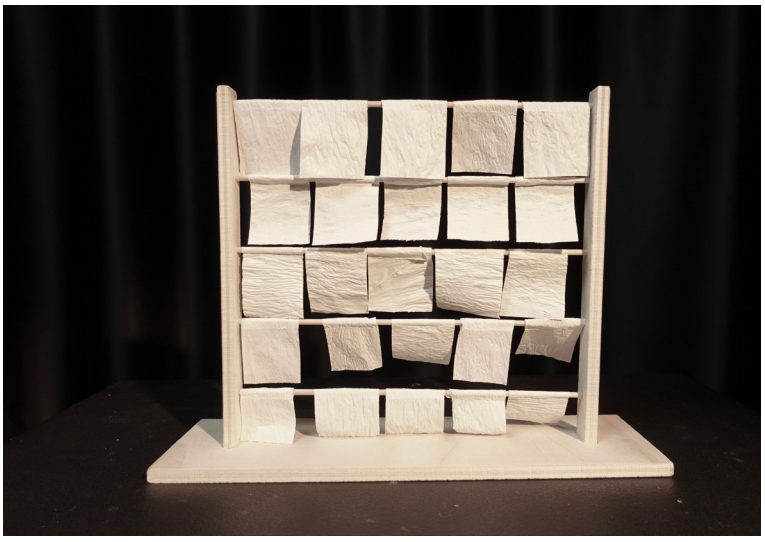
1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: thin, fringy and playful
3. Thickness: 0,5 mm
4. Method: heat, fused plastic bags
5. Tools: wooden sticks, plate and cutter
6. Durability: 1
Space defining: 4

 # 1.3

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: scales and loose
3. Thickness: 0,5 mm
4. Method: heat, fused plastic bags
5. Tools: wooden sticks, plate and cutter
6. Durability: 1
7. Space defining: 4



 # 1.2



 # 1.3

Colour

So far I only worked with white plastic bags but what about introducing coloured ones? Therefore I introduced coloured plastic bags, which I fused randomly together. Signs, letters and patterns can create a nice effect or can be distorted when the plastic gets heated.

For the colour experiments I cut the sheets in 25 by 5 cm. Then I layered them on top of each other. As a structure I took 2 wooden sticks, which are held together on the top and on the bottom with a wooden plate. The plastic material has holes, where it meets the sticks in order to get fixed. This arrangement of plastic sheets is very natural since it is easy to stack planar material on a helping structure. The edges create a curling border and from the distance it creates an intriguing image. The second experiment consists of black plastic bags, which I cut into stripes. As a base I soldered a grid and attached it on to a wooden plate. Then I could start weaving the material with the grid as boundary condition. The end result gives a dark and covering impression with a rhythmic pattern.

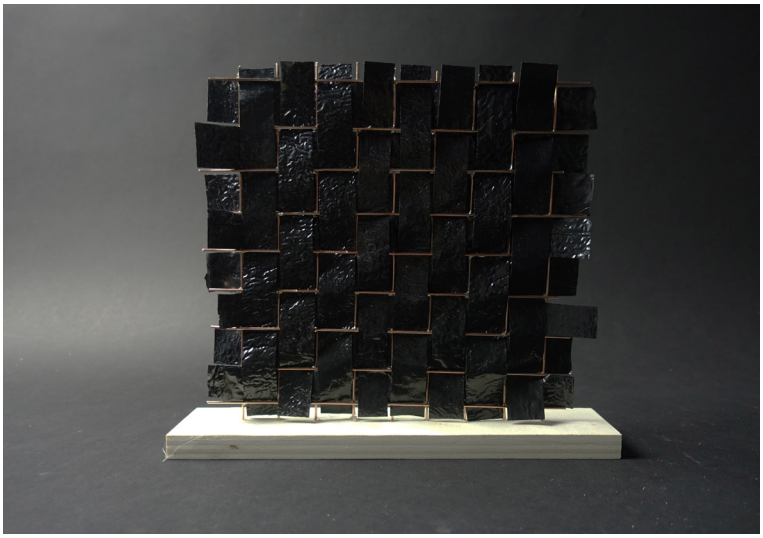
 # 1.4

1. Type of plastic bag: 4 layers of coloured LDPE
2. Appearance: layered, wavy, soft and semi compact
3. Thickness: 5 cm
4. Method: heat, fused plastic bags
5. Tools: wooden sticks, plate and screwdriver
6. Durability: 3
7. Space defining: 5

 # 1.5

1. Type of plastic bag: 4 layers of black LDPE
2. Appearance: weave, opaque and shiny
3. Thickness: 1 mm
4. Method: heat, fused plastic bags, welding
5. Tools: metal grid, plate, soldering iron
6. Durability: 4
7. Space defining: 5

 # 1.4



 # 1.5

Material

When experimenting with plastic bag membranes, I also want to introduce other materials and observe how they influence each other. The plastic embodies then a passive or hybrid role and the focus is not only on one material. However since the shape of the plastic membrane is very flexible it can be adapted to shapes of solid matter.

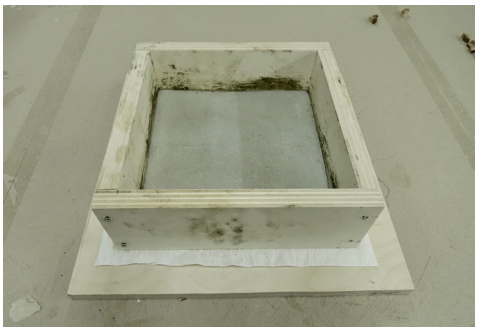
For this round of testing I used natural stones and melted planar plastic around it. I started to wrap the stones in plastic sheets (like a present), and then I used the hot air gun for melting the plastic around the inner material, which should be not sensitive to heat. This process is less controllable, so the outcome of the shape is always a surprise. Depending when you end with heating the material, the plastic or the stone is more dominant. After a long time of heating the plastic becomes holes and the stone underneath gets visible. I appreciate the irregularities or unique moments of this method.
The second test was to pour concrete into a wooden framework with a plastic membrane on the bottom in order to get its texture as imprint. I tried to minimize air bubbles in the material by vibrating motions, however the surface still includes little cavities, which is likewise the imprint of the plastic surface.

 # 1.6

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: juxtaposition, soft and hard
3. Thickness: varying
4. Method: heat, fused plastic bags, stones
5. Tools: hot air gun
6. Durability: 5
7. Space defining: 4

 # 1.7

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: massive, wavy & bubbly texture
3. Thickness: 2 - 3 cm
4. Method: casting concrete
5. Tools: wooden form work, concrete and water
6. Durability: 5
7. Space defining: 5



 # 1.6

 # 1.7

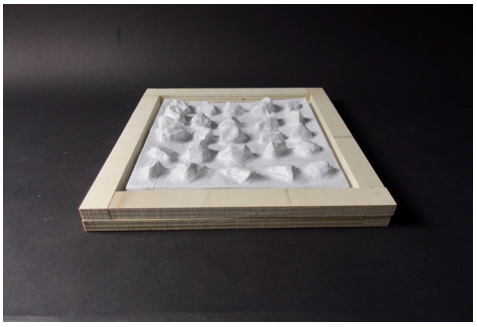
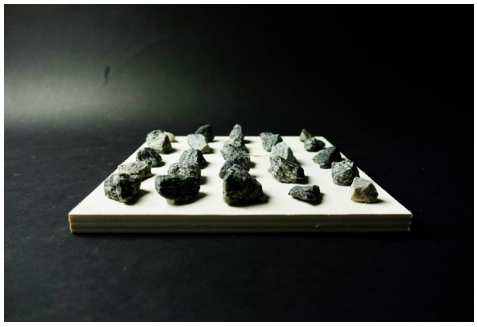
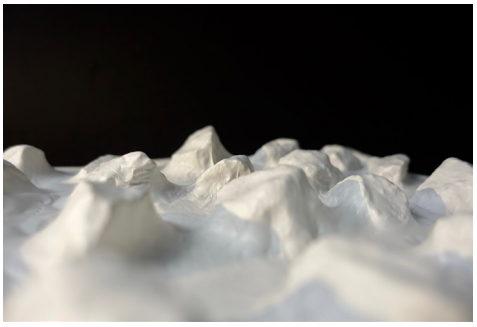
Texture

In my preparatory course I mainly worked with artificial produced textures. But what about using already existing ones? This would be more sustainable in terms of material and time. And what about seeing the texture as a reflection of the surrounding? For example stones, gravel, wood or mussels. For the experiment I used a wooden frame in order to attach the plastic bag membrane. After heating the material with a hot air gun, it could be pulled over the texture or object.

For this theme of experiments I took stones from nature. I composed them on a wooden plate, in an ordered manner. The next step was trying to heat the plastic sheet (with the hot air gun) and pressing it by hand over the stone arrangement. This method was less successful as one could see only slight changes in the surface. Therefore I again used the vacuum machine in order to get deeper and more precise texture. So the plastic bag membrane has now the imprint of natural matter, which I find more intriguing than CNC cutting a foam model, where the control is very high and less accidentally. Also I prefer to combine high technical methods with low technical ones.

 # 1.8

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: lightweight, hollow and tactile
3. Thickness: 0,5 mm
4. Method: heat, fused plastic bags, vacuum
5. Tools: wooden plate, stones, vacuum machine
6. Durability: 2
7. Space defining: 4

 # 1.8

Collection II

Experiment II

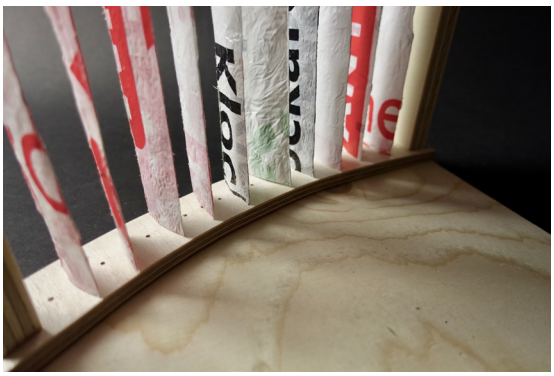
The second round of experiments is a continuation of the former but with a focus on lamellas, layers and stones. Two of the three experiments are framing the material by suggesting the idea of components. The structures that carry the material have a functional purpose but they also treat the material as wall or facade elements. Therefore the focus lies more on the system and less on the materiality. However the third element (stacking stones) is a combination of material and structure, that supports the idea of working with the characteristics of the material and emphasising its capabilities. The intention is to have the material as present as possible for triggering interesting and surprising moments.

Lamellas

For this experiment I tried to build a system with vertical lamellas made out of plastic bag material, that are inserted into a wooden frame. Due to its lightweight manner, the underlying structure and the material attached to it are moving very easily. The position of the lamellas can change from open to closed and thereby it creates a moveable wall reacting to outer influences. Since the material is depending on the structure, the plastic plays a minor role and it is merely a reflection of the symmetric and linear system than being able to unfold its whole potential.

 # 2.1

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: symmetric, systematic, moveable
3. Thickness: 0,5 mm
4. Method: heat, fused plastic bags
5. Tools: metal sticks, wooden frame, soldering iron
6. Durability: 3
7. Space defining: 4-5



 # 2.1

Layers

The layer experiment is a direct continuation of the former experiment. It consists of stacked layers of plastic bag material threaded on wooden sticks and hereby creating density. The result is a wall component, which gives an irregular, soft and lively image. In order to create some difference to the former experiments, I used the heat gun and melted the material together to one compact piece. Hereby the plastic bag material increases its density and hardness. Plus it shrinks around the carrying structure.

 # 2.2

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: wavy, irregular, laminated, textured
3. Thickness: 0,5 - 150 mm
4. Method: heat, fused plastic bags
5. Tools: wooden structure, hot air gun
6. Durability: 2-3
7. Space defining: 4

 # 2.2

Stones

Since I have experimented with melted plastic bags around stones in the first round of testing, I am trying to develop this method further, where a hybrid wall is created. Before starting to stack the wall, I had to wrap all stones with the plastic bag material and prepared a structure made out of metal sticks, which is guiding the location of the stones. First I started to heat the plastic around the stones and then I could start with stacking. I used additional plastic bags for melting the stones together and creating a firm connection between them. This method shows the potential of plastic bags fusing with another material such as stones, where plastic gets heated almost to its maximum before getting fluid.

 # 2.3

1. Type of plastic bag: 4 layers of coloured LDPE
2. Appearance: irregular, melted, hybrid
3. Thickness: 5 cm
4. Method: heat, fused plastic bags around stones
5. Tools: metal sticks, hot air gun
6. Durability: 4-5
7. Space defining: 5

 # 2.3

Experiment III

With the third round of experiments I narrowed the tests down to two methods of how to use plastic bag membranes. The first one is stratification or layering of the material and the second one is stacking plastic, that is melted around stones. Hereby the focus lies more on the material itself and less on the underlying systems. I explored different ways of arranging the material, which are connected to architectural spaces and are situated in the scale 1:20. The vertical arrangements are comparable to columns and the horizontal arrangements to ceilings.

Collection III

Plastic layering

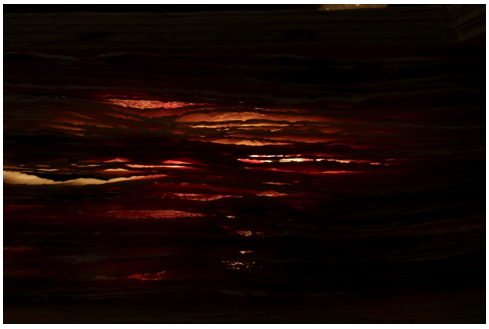
One method of focus is layering or stacking plastic bags, that are cut in identical sizes and shapes. I was experimenting with two different arrangements - the first one was creating four vertical stacks, that is mimicking columns. The system is rather structured but the material adds some randomness and liveliness to it. Plus the quality of translucency is created by layering the material. Therefore the "columns", that are only hold by a wooden stick have a lightweight appearance. The second arrangement is an exploration of the material in the form of a ceiling. The clear cut of the material stands in contrast to the wavy seams. However this adds an interesting feature, since it is against the nature of plastic bags, which are not linear or systematic when in use.

 # 3.1

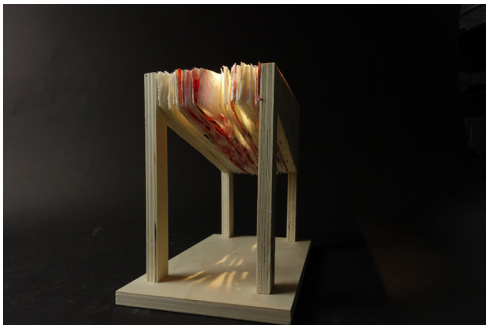
1. Type of plastic bag: 4 layers of coloured LDPE
2. Appearance: layered, vertical, structured
3. Thickness: 40 cm
4. Method: heat, fused plastic bags, stacked
5. Tools: wooden sticks, wooden plate
6. Durability: 3
7. Space defining: 4

 # 3.2

1. Type of plastic bag: 4 layers of coloured LDPE
2. Appearance: angular, translucent, layered
3. Thickness: 10 cm
4. Method: heat, fused plastic bags, stacked
5. Tools: wooden sticks, wooden frame
6. Durability: 4
7. Space defining: 4



 # 3.1



 # 3.2

Characteristics of plastic layering

I chose to focus on the plastic layer method since it has a strong expression. Hereby the plastic bag membrane is seen from another perspective. After layering the material, the elevation of the system is the visible part and likewise the different coloured sheets. This creates a very playful and natural image, which almost reminds of a pattern, that can be found in nature such as layers of sediment. However here the material is soft and flexible. Plus the sizes of the sheets but also the layering direction can vary. Therefore this is a versatile system, that is simply supported by sticks.
I also appreciate the different facets of the material. Depending on the direction of light and view, it is either translucent, opaque or a mix of it. In addition using coloured plastic bags creates an interesting image.
By tracing over the photo of the material I extracted characteristic information that are part of the material gesture and that get explained in the following.

 # Ripples

The ripples are traces of the fusing process. The material contradicts and creates that tactile texture when exposed to heat and it varies in its intensity. Due to the ripples the material gets a micro texture, that adds a natural touch to the material.

 # Waves

The waviness is a very typical feature of the soft and flexible material. Since the waves are random and completely different in its size, it creates playfulness. Plus the waves are also breaking the symmetry of the system.

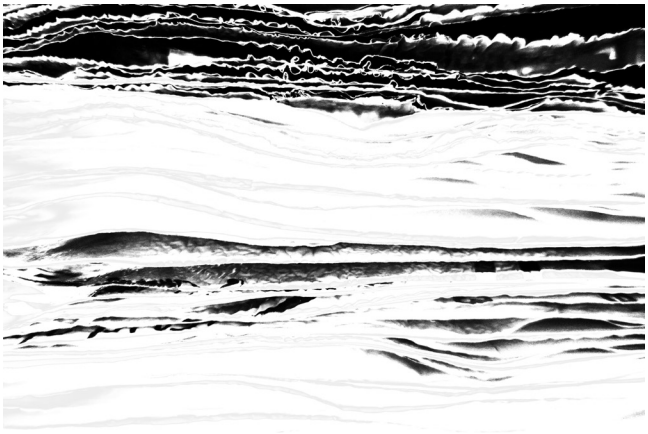
 # Translucency

The material has areas, where one can see through. This introduces the aspect of translucency - light can come in and depending on the intensity and direction the appearance of the material can differ.

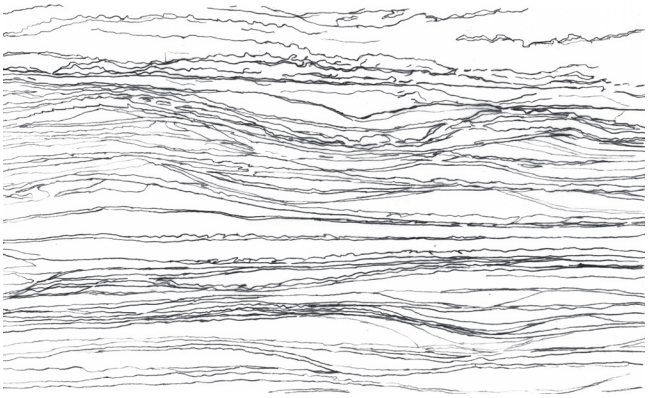
 # Depth

The plastic layers are only seen in its section. However depending on the size of each layer depth can be generated. A former planar material can be turned into a three dimensional arrangement. The aspect of depth makes the material more compact and space defining. In addition the gap in-between the layers are creating a sense of depth.

Base photo I



Photographic extraction I



Contour drawing I

Plastic stones

This is the second method, on which I am focusing - stones covered with recycled plastic bags. Instead of cutting, heating is the dominant factor of arranging the material. The vertical stacks appear very natural and less systematic although they are placed in a symmetrical order. The irregular melted expression of the material emphasises this even more. The second arrangement explores the materials potential of creating an arch. In order to melt the material together additional layers of plastic is needed. The arch starts with a solid foundation and turns into a fragile upper part. An interesting feature is the translucency of the method. Due to holes and gaps in between the stones, light can shine through.

 # 3.3

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: melted, irregular, vertical
3. Thickness: 5 cm - 1 cm
4. Method: melted plastic bags around stones
5. Tools: wooden plate, hot air gun
6. Durability: 4
7. Space defining: 4

 # 3.4

1. Type of plastic bag: 4 layers of white LDPE
2. Appearance: fragile, curved, irregular, melted
3. Thickness: 4 cm - 1 cm
4. Method: melted plastic bags around stones
5. Tools: metal sticks, wooden plate, hot air gun
6. Durability: 3
7. Space defining: 4

 # 3.3

 # 3.4

Characteristics of plastic stones

The plastic stacking method consists of plastic bag membranes that are melted around stones. For me this created material is a contradiction, which in turn creates tension and therefore makes it very interesting. Artificial meets natural, soft meets hard and bright meets muted colour. Furthermore the dominant behaviour of the plastic material is in a way absurd. The plastic bag membrane has clear traces of the heating process, that is visible in the form of wrinkles and bubbles - so the honesty and obviousness of it is an appealing gesture. Plus the material is in a frozen state but showing movement at the same time. This is made visual in its wrapping around motion.

 # Layers

The layered effect is created due to several layers of plastic bag sheets, which are exposed to high heat. The visual appearance of it is soft but randomly. That creates a very lively feeling although the material is in a "frozen" state.

 # Juxtaposition

The combination of two diverse materials, stones and plastic bag membranes, creates an interesting play. It almost reminds me of the game scissor stone paper, where the paper beats the stone. The plastic is wrapped around the stone, being the dominant material in the outer layer. However one can recognise or imagine the underlying shape of the stones. So the stone is still very present but coated with plastic. At some points, where the impact of heat was high, the natural material gets visible.

 # Creases

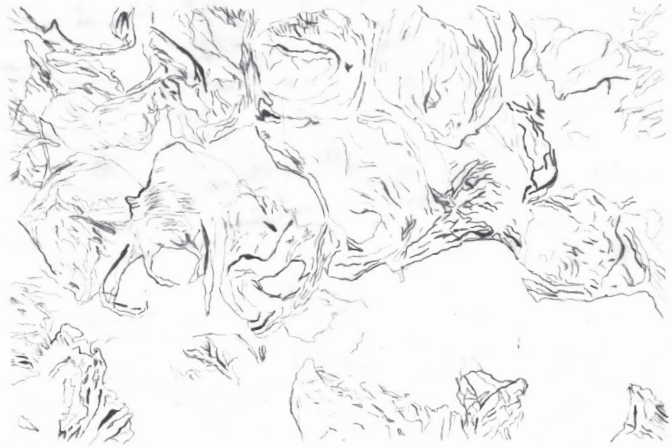
Due to the fusing process the heat creates creases, which is a characteristic feature of the plastic bag membrane. Those wrinkles are very natural looking although the material itself is artificial. Gestures like randomness and liveliness are created.

 # Curves

Another consequence of heating the material are the curves, which are softly floating without having straight passages. This makes the wall appear smoother compared to a regular edged stone wall. On the border of the material, the curves are more significant since the seam is thicker.

Base photo II

Photographic extraction II



Contour drawing II

Material gesture

"Material gesture", a term described by Anne Holtrop, emphasises the importance of the material properties and the unintended effect of an action with the material. (Anne Holtrop, 2013) "The architecture that results form this approach does not reference or represent something, neither is it an abstraction, but simply attempts to exist as a physical reality." (Studio Anne Holtrop) The truth of a material lies not in its refined and ideal composition, instead it can be found in its imperfectness. Influenced by Roland Barthes writings about Cy Twombly's work, a gesture is the surplus of an action. It can be also seen as the production of an effect while not searching for one. The art of Twombly consists of making things that are seen - not the things he is representing.

What means material gesture for my project?

Anne Holtrop's way of approaching his projects is very fascinating to me, often starting from outside architecture, plus having matter and form as the core of his creations. Since his work is not fully understandable, it leaves space for interpretation and allows to spread the poetic aspects even more. Trying to find material gestures in recycled plastic bags helps me in describing my process and creating an archive of various expressions.

So this unintended way of looking at the material of plastic bags helps me in finding interesting, exciting or precious moments. For me a gesture is not something fixed or defined, instead it is a comprehensive description of a material. The gesture of plastic bag membranes does not only imply the performance of it but it also refers to how we experience the material with our senses. Therefore doing physical model experiments and in the following taking photos of them is my way of reflecting on them and creating an archive of material gestures.

Thus the term material gesture is very essential for my project, since it is a constant reminder of my main intention and helps me to look beyond the material of recycled plastic bags. During the whole process of testing I collected terms of characteristics with short descriptions, that explain the wide range of material gestures. However the more knowledge I collect about the material of recycled plastic bags, the more I am trying to channel it and focus on one specific plastic gesture, that aims for interesting, precious and beautiful moments.

Materials found on island Galterö

Terms of characteristics

 # Irregular

Due to the sensitivity to heat, the material has traces of melting in a very random order.

 # Bubbly

When heating the material, different sizes and shapes of bubbles are arising. It is the sign of too much heat and usually before the plastic is getting holes.

 # Perforated

Perforation follows after bubbles are appearing and it happens when the material has the maximum heat level.

 # Frizzy

Very thin stripes of cutting the material creates this effect.

 # Wavy

Melting several layers together results in a pattern of wavy lines and wrinkles.

 # Hybrid

The combination with another material shows the plastic bag in a hybrid arrangement, where it adapts and tries to follow the counter material.

 # Elastic

It describes the possibility of changing the shape of the material without resistance.

 # Soft

The plastic material itself has a soft surface and the flexibility of the material emphasises it even more. Plus the texture of the material has no sharp edges, so it feels quite smooth.

 # Stretched

If the direction of creases are dominating in one direction, it is stretched. In addition the materials thickness is thinner than normally.

 # Glossy

Depending on the kind of plastic, the membrane appears glossy. For instance black plastics reflect more light and therefore has more reflection.

 # Opaque

Depending on the amount of layers and thickness, the plastic bag membrane is not translucent any more.

 # Translucent

This characteristic is depending on the amount of layers and light sources.

 # Layered

The plastic bag membrane consists of several layers of fused plastic bags and since the heating process is not equally, the edge shows a sense of layers.

 # Playful

Changing forms and colours are creating playful situations. Plus the texture of the material supports this expression even more.

 # Fragile

Plastic bag membranes are per se a light material but at the same time very robust (concerning water and chemical influences). Depending on the method of transforming the material, it can represent fragility.

 # Wobbly

The material needs to be attached in order to work as a space defining element. If the ratio of plane and attachment is unequal, the membrane tends to be wobbly. Plus the direction of fixture is another influencing factor.

 # Mistakes

If the material is exposed to too much heat, unwanted results can arise, which are not controllable to a certain degree.

 # Spontaneity

Due to the fact that the material's reaction to heat cannot be precisely planned, spontaneous moments are to be expected.

 # Uniqueness

The former description of spontaneity creates a material with unique appearance that cannot be mimicked.

 # Bulky

Stacking melted plastic stones is rather unregulated and shapeless in its form. It almost appears alien and thus having an ugly appearance.

 # Contrast

Combining artificial and natural matter is contrasting in its own. However contrast can be also found in the way of arranging the material compared to its former use.

4.0 Selection

Material description

An original flat plastic bag is turned into a three-dimensional system with spaces of air in-between. It simply consists of loosely packed layers of surfaces, cut in the same size and stacked on each other in parallel manner. Due to slight waves with its significant edges and changing colour it has almost a natural expression. In addition the lightness of the material and its loose arrangement create a lively character, especially when exposed to wind. Each single membrane is 4 layers of plastic bags thick and because of the prior heating process the texture has tiny creases incorporated. The gaps in-between the layers can vary from 1 millimetre up to multiple centimetres and the angle of view influences the appearance of the system. For instance the frontal view makes it possible to look through the gaps, whereas a tilted perspective does not. Depending on the direction of light and view, the material is either translucent, opaque or a mix. Plus the density of layers influences this aspect. In addition plastic bags are differently coloured, therefore the variety of colours becomes a feature for the system and creates an accidental change of colours. The method of layering plastic membranes creates also tactile sensations that gets triggered by touching the textured surface. For me it feels very soft and bouncy if you add pressure to it. Due to the looseness of the system it can be affected by wind and makes a specific plastic sound, which is a vivid rustling noise.

Frontal view

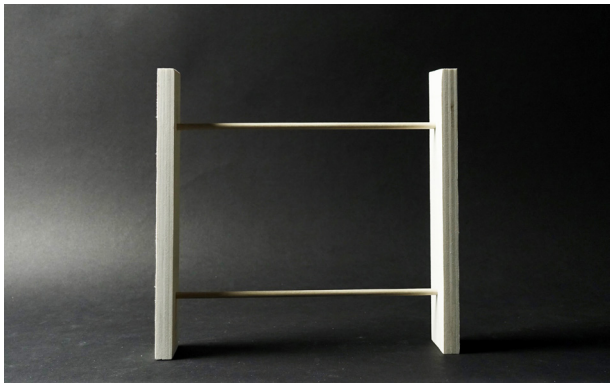
Tilted view

Tactile experience

Structural system

Since the method has no load bearing properties it needs a helping structure, which additionally keeps the material in place. Therefore the plastic bag membranes are a filling material, pierced on rods and attached to a plate or frame for stabilisation. The points, where the material gets pierced are in the centre of the surface in order to expose the plastic material and leave the structural system in the background, similar to a skeleton. Plus it follows the logic of creating a lightweight and flexible filling material. The plastic material does not slip away because of friction created between the meeting of the material and the rods.

The dimensions of plastic bags determine the size of each plastic stripe. (One sheet of plastic bag membrane is around 40 x 50 cm large.) Once the stripes are cut in identical rectangles each hole must be marked onyy<<<ged using metal and finally using LED sticks to achieve an integrated lighting effect. The LED stick is a 2 in 1 system, since it is a structural and a lighting element at the same time. Depending on the size of the gaps in-between the layers, the stick gets visible or not. In my 1:1 material test the structural system is 30 cm wide, however I see the possibility of using rods, that are 100 cm long, which creates a 1 metre wide filling material and can be simply inserted in load bearing side elements.



Structural skeleton

Layers versus gaps

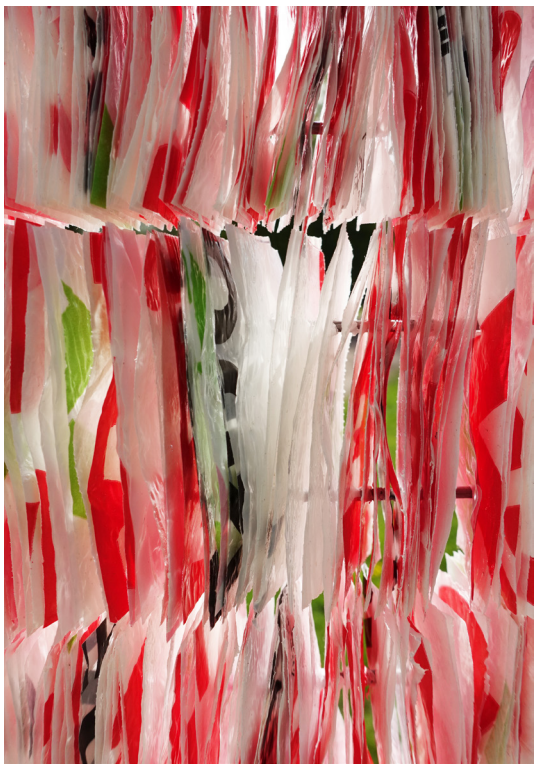
Friction detail

Qualities

After exploring various methods using plastic bag membranes, I decided only focusing on the technique of layering the material, that gets pierced on rods. This method is rather simple, yet the bigger picture created by it is very complex and full of potentials. Plus I find that this method expresses the qualities of plastic surfaces at its best because the planarity of the material becomes a feature.

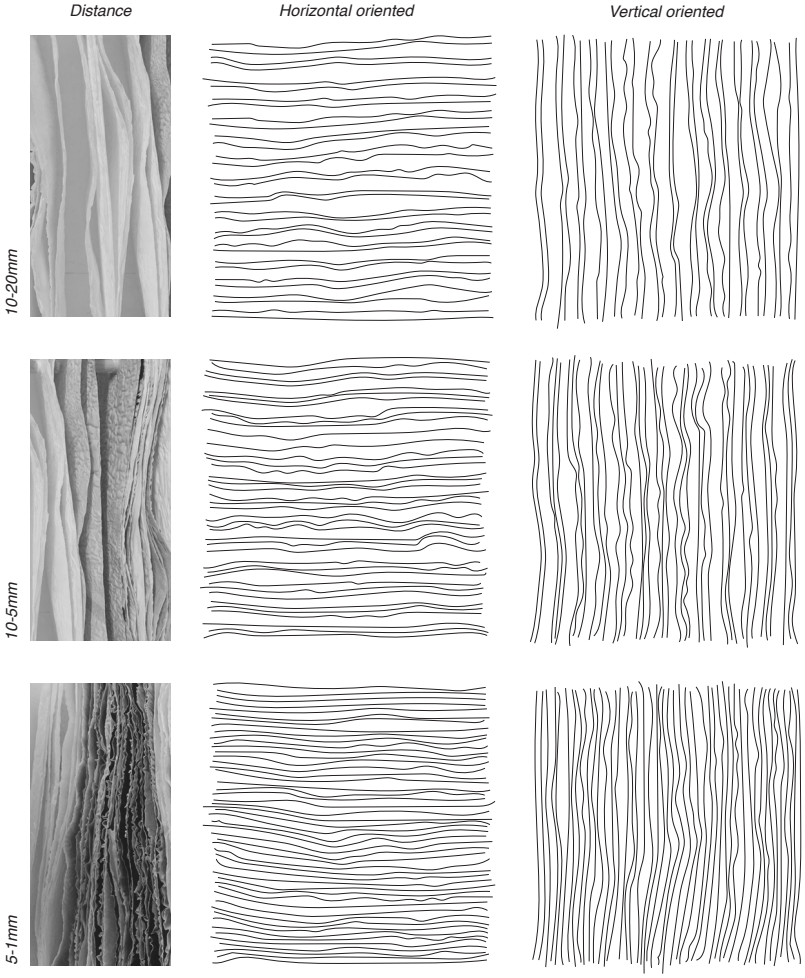
One quality is translucency, that operates on two levels. Firstly it is the translucent characteristic of the material itself and secondly it is the different sized air gaps in-between the layers that generate translucency. Therefore the method creates intriguing moments in combination with light and additionally it changes its appearance drastically depending on the light situation. That leads to the qualities of a versatile and flexible system because the plastic bag membranes can be manipulated, that in turn changes the distance of gaps in-between the layers. The ability of moving the layers triggers also playfulness since one can rearrange the material and leave a personal touch behind.

In addition I want to mention the quality of creating a fascinating and almost beautiful material, that is mainly subjective. However I argue that the ordered arrangement of recycled plastic bags that are otherwise situated in a context without order creates beauty. Thereby the material is treated in a precious way in order to create a repetitive and geometrical arrangement. And since an unwanted and disposed material gets a new purpose with value, this shift of paradigm is beautiful for its own right.



Material in daylight

5.0 Possible application


Distance
Horizontal oriented
Vertical oriented
10-20mm
10-5mm
5-1mm

Layered material

Layers of fused plastic bags are the starting point for the possible application. In the further course the material will be developed into a space defining element that follows the logic of layering. Therefore the subsequent design process starts with layering elements, layering space and layering experience. The element brings recycled plastic bags into an architectural context, where the semi-dense character is a key feature. It is depending on the thickness of the layers and the distance between them, which also influences how much light can permeate. Plus the orientation of the layers can be either horizontal or vertical.

Layered elements

Since I work with the method of stacking plastic bags that are framed by another material, elements are created. They can be stacked to a bigger entity and the consequence is to investigate in the different ways of layering and in the further steps creating spatial qualities.

I explored several ways of layering the elements, starting with a simple wall, continuing with columns and introducing more complex shapes. I realised that the seam between the stacked elements is a very dominant aspect, that creates rhythm and symmetry. It is also were the irregularities of the plastic material meets the preciseness of the load-bearing system. Layering the elements means also to consider the double-sided nature of it. There can be a visual balance between the recycled plastic material and the framing material or a dis-balance, where for instance the plastic bags are the dominant surface. Furthermore if the modules are stacked in the z direction the aspect of translucency gets lost. There is also the possibility of layering unfilled elements or creating openings by stacking them in a certain way. What all the iterations have in common is layering elements in the form of a wall or a column, that are based on a grid. This grid creates rather strict boundary conditions however there are various ways of how to compose the elements within this system.

 # 1.1
Elements get horizontally and vertically stacked to create a space defining wall. The structure expresses clearly the orthogonal grid.

 # 1.2
Elements get layered in x, y and z direction with an incremental decrease. Three dimensionality is created.

 # 1.3
Stacking elements around a small square shaped void creates a column like structure.

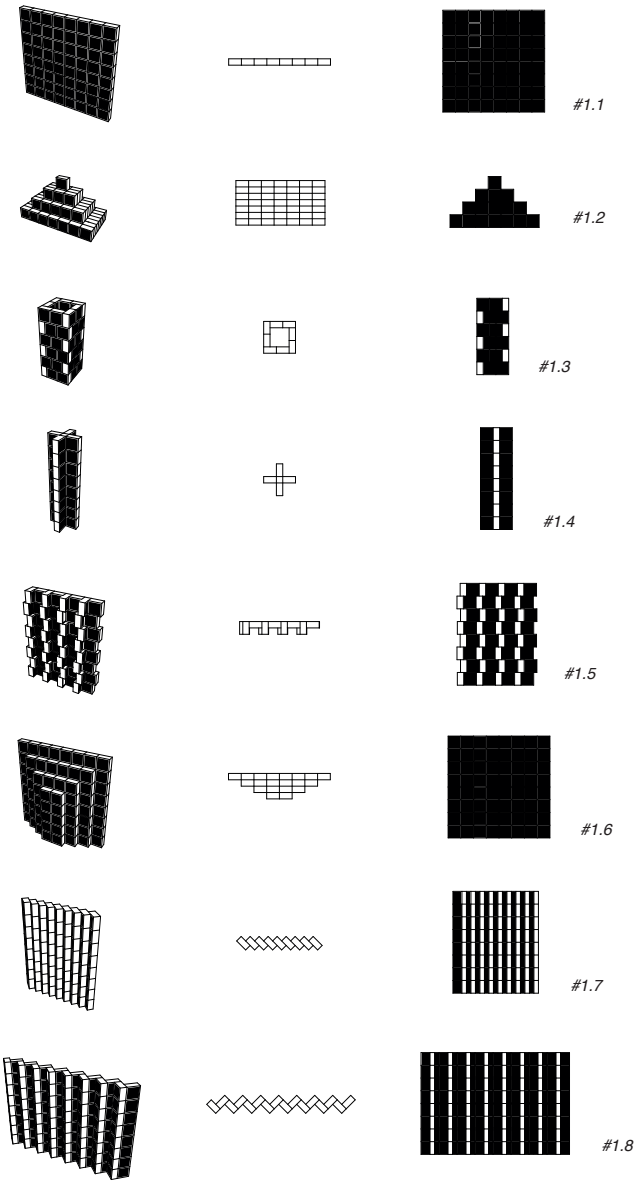
 # 1.4
The modules are stacked in a cross in the vertical direction and express the double-sided nature of the element.

 # 1.5
Stacking modules, that are oriented in two different directions, create a wall with a rhythmic relief.

 # 1.6
Here the elements are layered with an incremental decrease in the horizontal direction, that creates depth and a symmetrical play.

 # 1.7
The elements are stacked 45° in the horizontal direction. This breaks the otherwise orthogonal system.

 # 1.8
Another version of non orthogonal stacking in the x direction, that creates a zigzag shaped wall.



5.1 Possible application

Layered space

The layered space is a development of the layered elements, that focuses more on the space that arises than on the actual modules.

The nature of the elements that are based on a grid is also reflected in the spatial arrangement. That is why I experimented in repetitive spaces, that follow a certain pattern and create a rhythm. Parallel layered space can be altered by changing the distance in-between the walls but also the height of the elements can influence the space. The main characteristics of the element shaped spaces are strong senses of direction, rhythm and grid based spaces (non organic). The layering of space enables to add density by simply multiplying and variety by graduation of the elements. The Swiss sound pavilion by Peter Zumthor is a good reference in that context.

 # 2.1
Walls are stacked in parallel manner with a narrow space in-between. It defines the space in one direction.

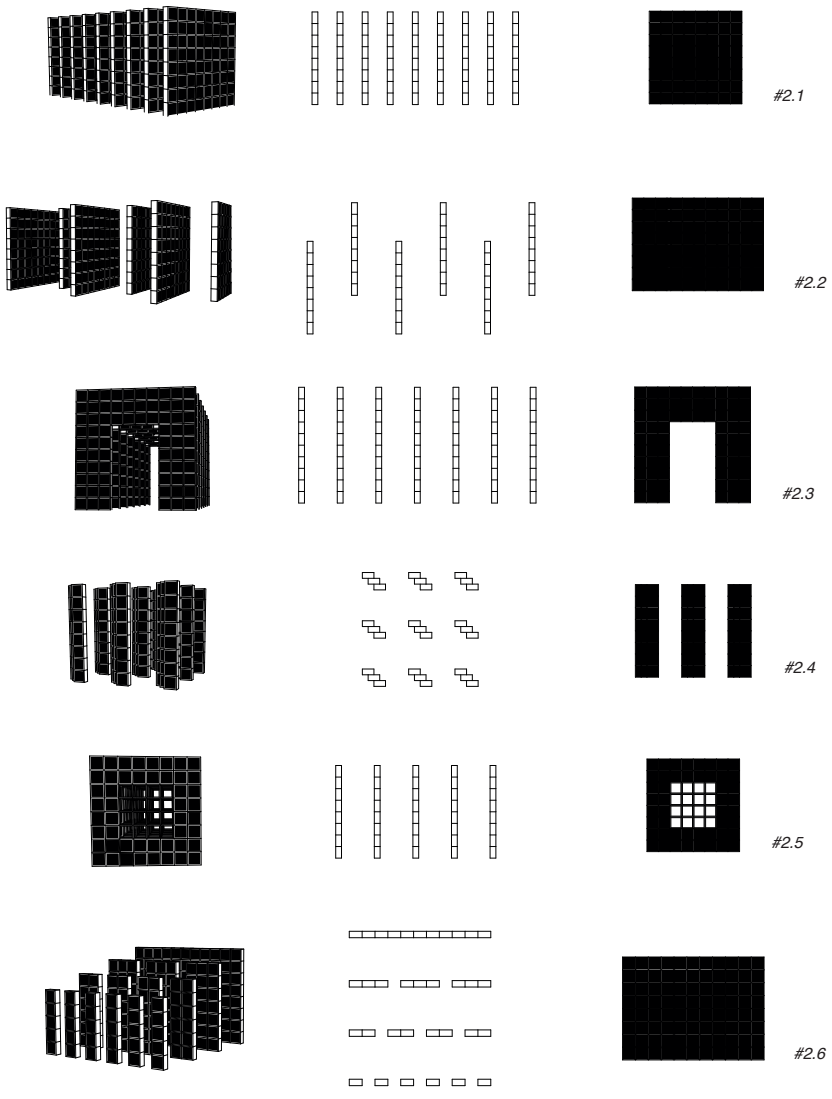
 # 2.2
Walls are stacked parallel again but horizontally they are not in one line and the distance in-between is wider. It has a more dynamic character and openness.

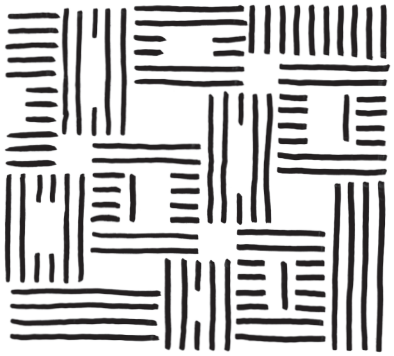
 # 2.3
Here layered spaces are created by walls that are pierced with openings. This offers a walk through and introduces the human aspect.

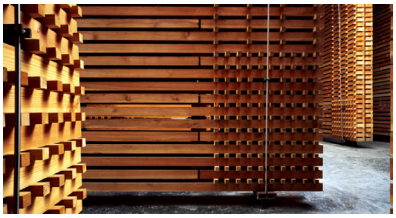
 # 2.4
Due to punctual layering of elements a grid shaped space is created. It has a feeling of openness and a two directional dimension.

 # 2.5
Walls with openings, where the plastic material is left away, are stacked. It creates a see-through and not a walk-through space. There the grid is more dominating than the filling material.

 # 2.6
This spatial arrangement starts with columns and gradually becoming a wall. There is not only a gradation in the horizontal dimension but also in the vertical, where the height of the space changes along with it.


#2.1
#2.2
#2.3
#2.4
#2.5
#2.6





Swiss sound pavilion, Peter Zumthor, 2000

Swiss Sound Box

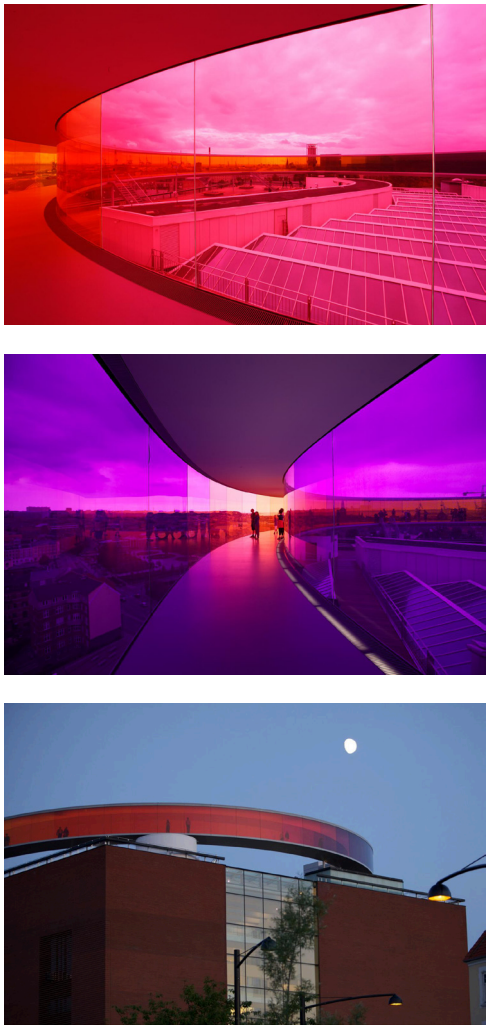
The pavilion designed by Peter Zumthor was the Swiss contribution to the Expo 2000 in Hanover and followed the sustainable theme "Man, Nature and Technology". The walls, stacks of 118 individual wooden elements, are held together with post-tensioning cables and linking planks between four walls. This creates the basis for the modular system through the whole structure, that is in no need of glue or nails. (Nurözler and Ma, 2015)

The porous design of the pavilion intends to be an acoustic space created by the material's quality and height, that serves as a place to socialize, explore and relax. By arranging the space in a basket weave way, layers of material, space and experience arise. It can be separated in three different modules, which is circulation, performance and dining. During its 6 month existence the pavilion offered orchestral performances, bar and food areas. After the Expos' end the structure could be disassembled and recycled.

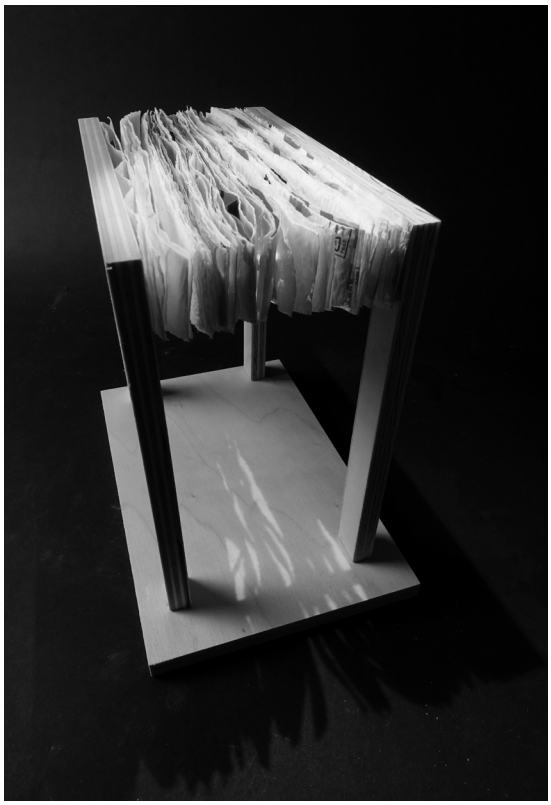
Light and colour

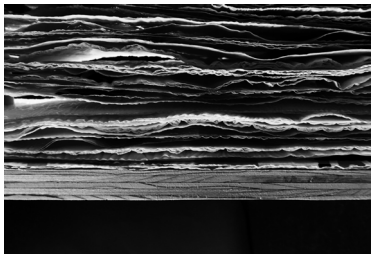
Colour appears to be on the surface being merely a superficial aspect of materials. However it has a lot of information embedded that can reach from creating a sense of space, perceiving forms to conveying feelings and emotions. (Swirnoff, 2003) The origin of colour comes from light that is separated into its spectral components. Therefore light is necessary in order to perceive colour. (Zwimpfer, 1988) By changing the intensity of light, colours are changing likewise. Natural light sources that change over the course of a day (sun) or that have flickering character (fire) bring liveliness to a material and space. Including the range of colours this aspect can be emphasized even more and a playful, vivid and interesting experience can be created. Regarding artificial lightning it is a more controllable light source, where the colour hues can reach from warm to cool, either creating soft or hard shadows. Plus artificial light sources are mostly static and especially effective without day light.

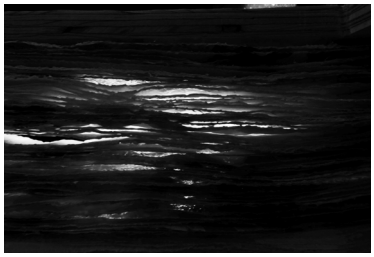
A good example for experiencing colour atmospheres is "Your rainbow panorama" by Studio Olafur Eliasson. The structure situated on top of ARoS Aarhus Art Museum is a 360° walkway that is glazed with rainbow-coloured glass and offers visitors changing views over the city. The structure with its distinctive colour zones is visible from far away and changes its appearance during the night when illuminated. "Your rainbow panorama" acts as a lighthouse, that brings attention not only to itself but also to the surrounding city. The colour intensities are a reaction to the speed of the visitor, either experienced as vibrant or blurred colours. (Studio Olafur Eliasson, 2014)



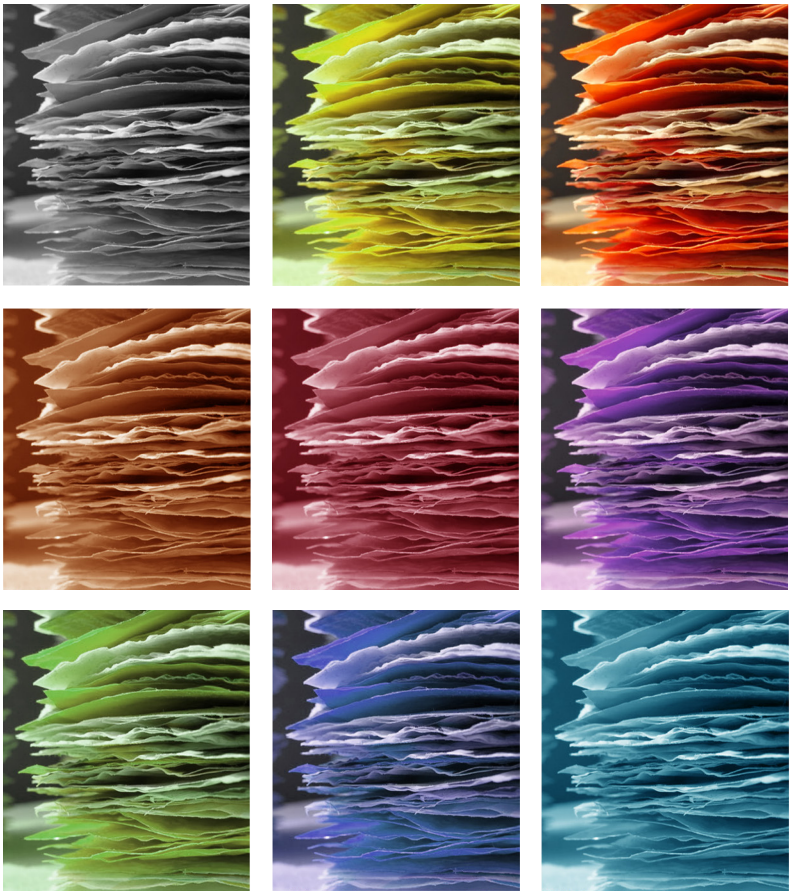
Aros museum, Your rainbow panorama, Olafur Eliasson, 2011



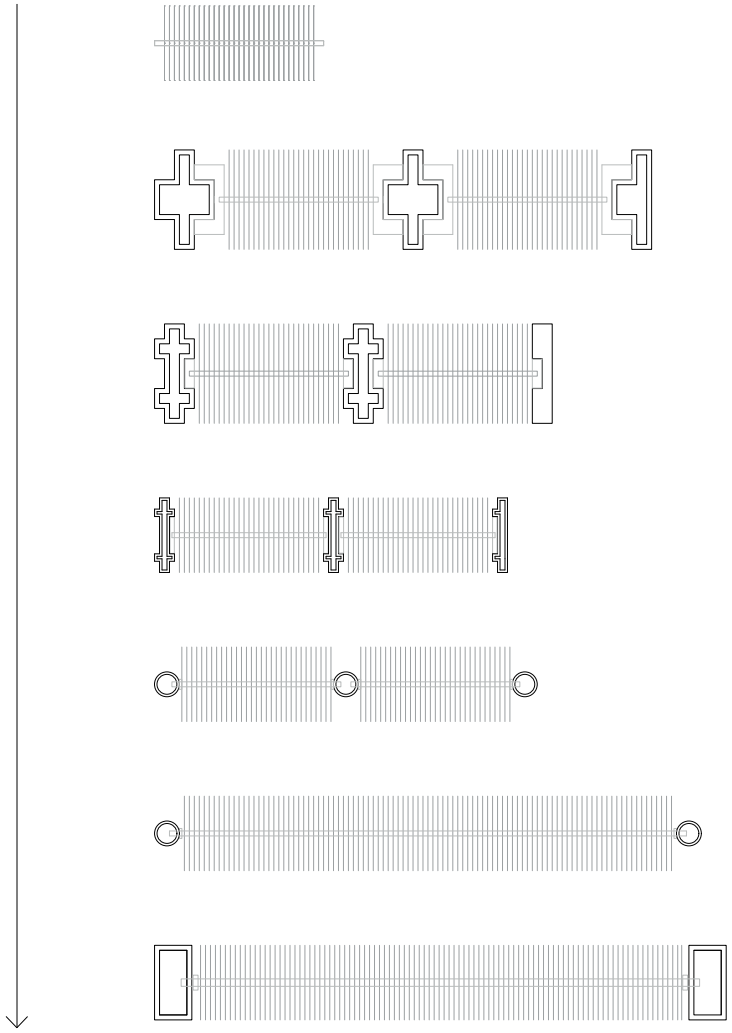




Lighting



Colouration



Process of wall system, plan view

Wall system

Having the recycled plastic embedded in a heavy wooden frame contradicts the idea of a lightweight structure with plastic bags as the main actor. Therefore the grid based structure gets reduced to as less material as possible. The final iteration contains metal poles as the load-bearing elements, that bring likewise the recycled plastic in place. It can be compared to a fence that punctually meets the ground. The plastic bag layers are pierced on rods that are plugged into the poles. Although the size of the plastic bag is vertically restricted to 30cm, horizontally the dimension can be chosen freely only depending on the distance of the poles. I chose to work with units of 1m. The height of the wall is likewise a reaction to the length of the poles, where the plastic layers get stacked in the vertical direction with 1cm gaps in between and ending 30cm above the ground. The result is a wall system that is neither solid nor opaque, instead it is lightweight, translucent, and lively.

Colour structure

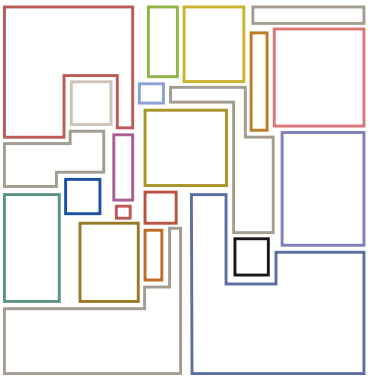
Robert Slutzky, artist and professor in architecture worked with the concept of colour structure and followed the tradition of colour field paintings. With his abstract geometric paintings he emphasizes the relationships between colour and form, proportion and composition. He stresses that paintings evoke the illusion of space, from flatness to perception of depth, whereas architecture tends to make real space become illusion. Therefore he sees a close relationship between painting and architecture. His paintings are normally based on grids, where complementary coloured squares are arranged by creating playful and vibrant visual art. In this way he continuously addresses the spatial relation between the painted plane and the architectural volume. (Swirnoff, p.129)

When looking at Slutzky's work it immediately evokes an architectural plan drawing, that consists of layered space articulated by colour fields. I can also see a connection to Zumthor's Sound Box, where a grid based structure separated into modules create vivid variations of space. Every colour field engages with another one and thus creating a homogeneous play of colour and form.

Layered experience

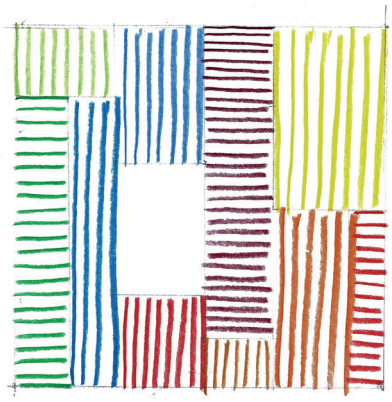
As a consequence to the previous tests of layering material, elements and space a combination of them results in layered experience, that is based on Slutzky's colour field technique. Those fields, starting as two dimensional geometric areas, turn into parallel lines and can be regarded as a plan drawing. In addition I tested how voids can be incorporated in order to create a counterpart to the spaces of circulation. Those light fields can be either additional colour fields or areas that get subtracted from the underlying colour fields. With this method I am able to create a design that is based on the material, the space, the colour and the light at the same time. Therefore the parameters are not seen isolated but rather as a cohesive ensemble.

Untitled No.1, Robert Slutzky, 1978, Oil on canvas



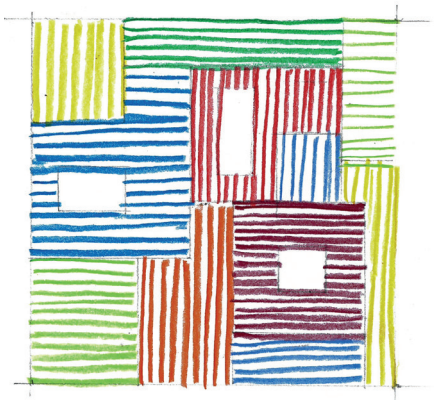
Spatial interpretation

Mixed colour spaces

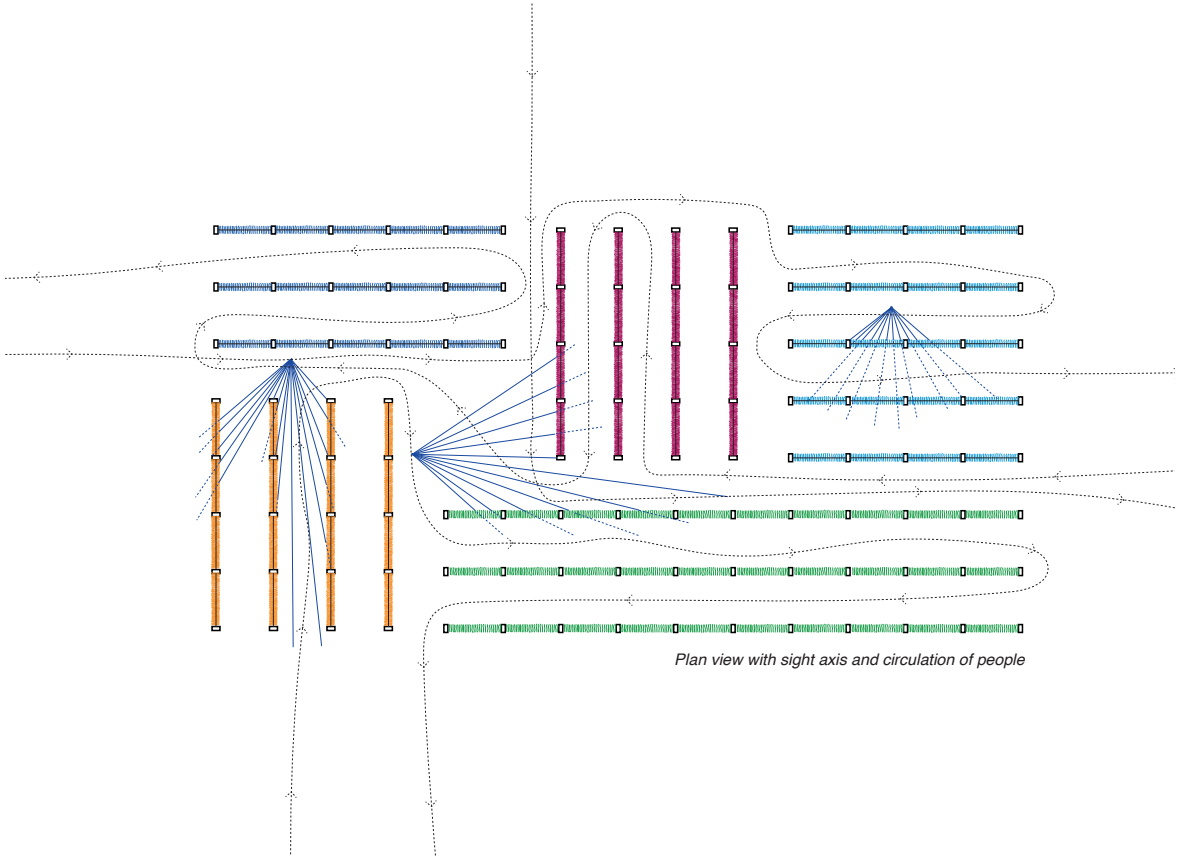


From cooler to warmer hues, linear fields

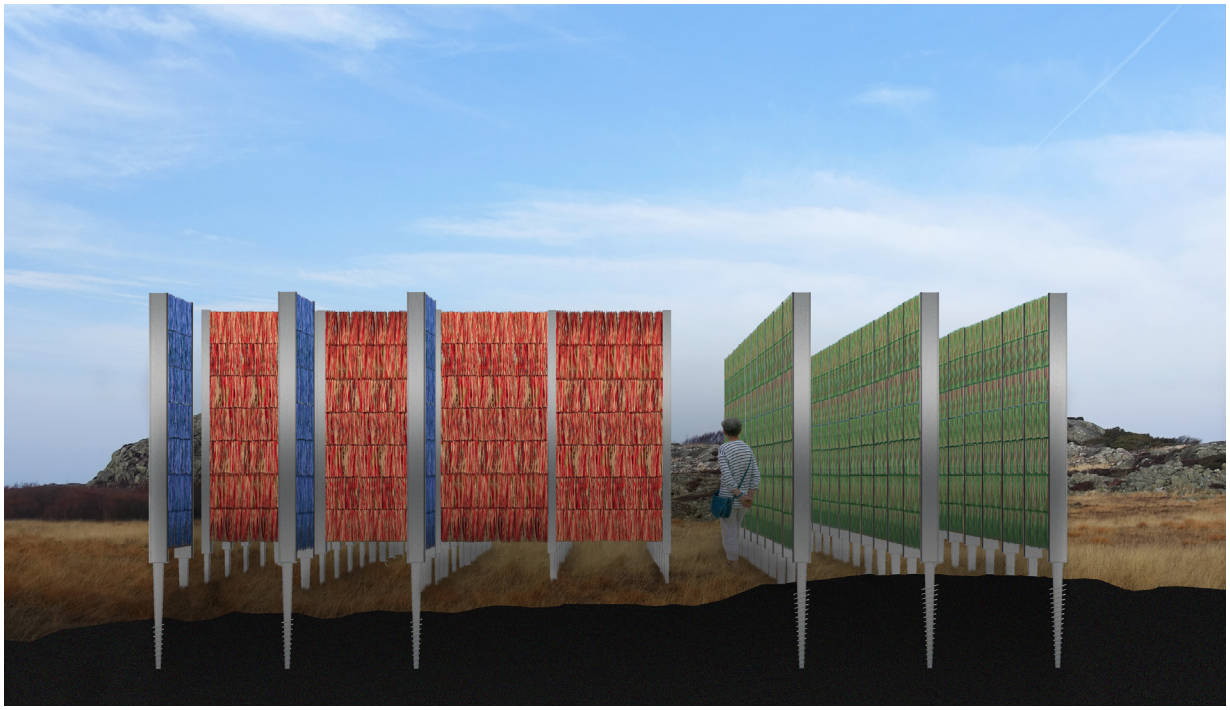
Voids as in between fields, diagonal layers



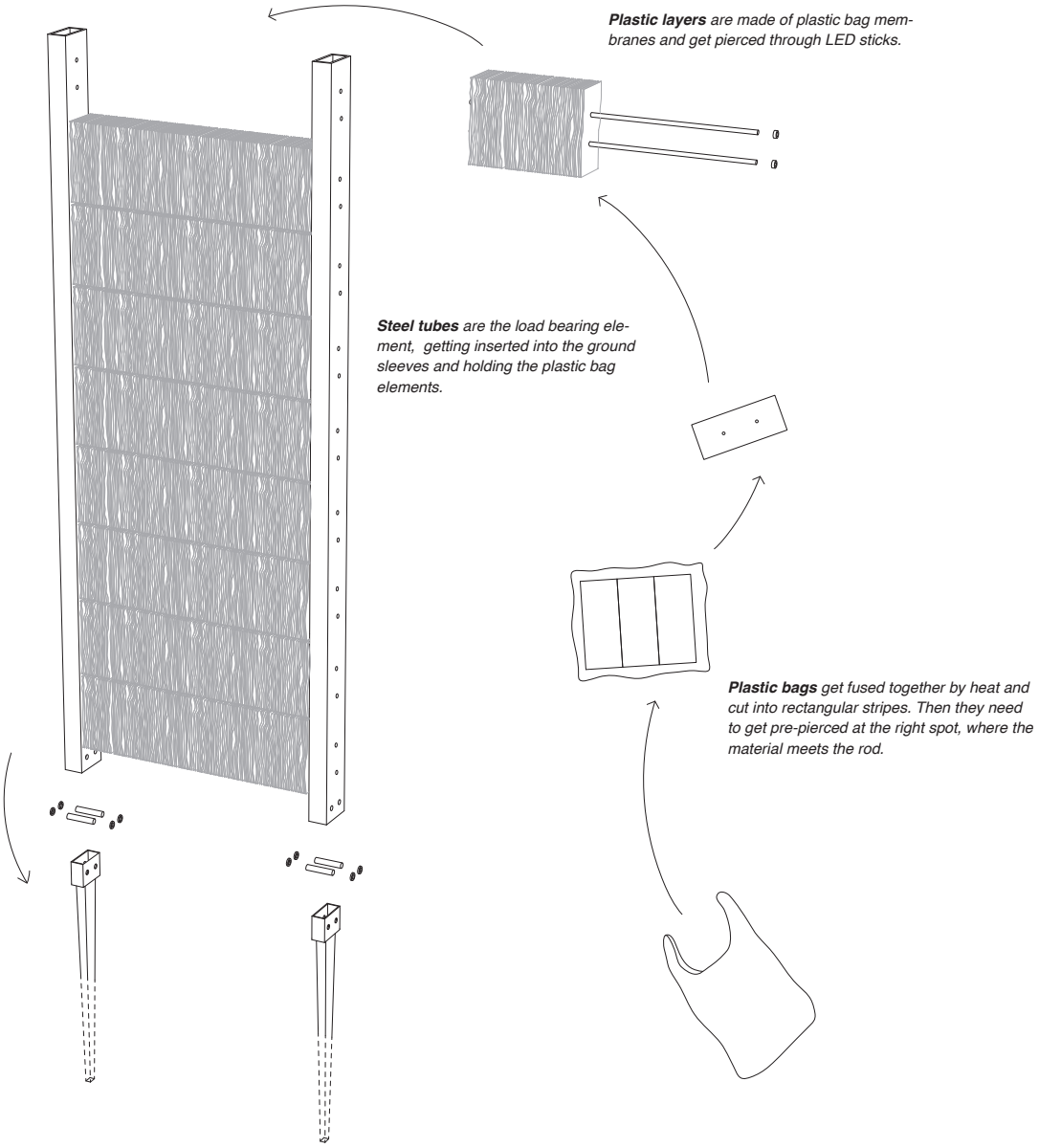
Voids within colour spaces



Plan view with sight axis and circulation of people



Perspective section



***Plastic layers** are made of plastic bag membranes and get pierced through LED sticks.*

***Steel tubes** are the load bearing element, getting inserted into the ground sleeves and holding the plastic bag elements.*

***Plastic bags** get fused together by heat and cut into rectangular stripes. Then they need to get pre-pierced at the right spot, where the material meets the rod.*

***Ground sleeves** are the foundation of the structure, that are anchored in to the ground.*

Material experience

Plastic pavilion

The purpose of the plastic pavilion is simply the experience of the material that get enhanced through integrated LED lighting. The layout of the pavilion derives from Robert Slutzky's colour structure technique, where I translated every field of colour into parallel walls, which comes from the thought of layering material, layering elements and layering space. The pavilion can be entered from every side and through narrow and linear corridors with different colours the recycled plastic material can be experienced. The centre of the structure contains a small void in order to create a counterpart to the linear paths and a place for contemplation. During night the appearance changes since the LED lights create an integrated light effect in every wall element.

The created wall system is one possible answer for applying the recycled plastic material and the pavilion a test of how the wall could work spatially, where the space is a consequence of the material itself following the same logic of layering. However the method of layering plastic membranes could be developed further for instance into a roof system, where it has watertight characteristics similar to a shingle facade. Since the plastic material has translucent characteristics it could also work as a filling material for openings similar to glass panels.

Pavilion situated in landscape

6.0 Light tests

Light and layered plastics

Since one of the characteristics of plastic bag membranes is translucency, light plays an important role in emphasising this quality of the material. In addition light adds a certain preciousness or beauty to the plastic material that makes it more appreciative and valuable. Therefore the following light tests are a crucial part of my thesis that bring me closer to my intention of finding precious gestures in recycled plastic bags.

The tests were conducted with natural and artificial lighting, that are separated in direct, indirect and integrated light. The direct natural light is sun light and the indirect natural light is indirect sun light or diffused daylight generated by clouds. The artificial light tests took place in the light lab, where the artificial direct light gets created by spotlights and artificial indirect light by soft boxes, that diffuse light evenly. The integrated light source are LED sticks.

For all tests I used the camera Sony DSC-RX100 M3 - a pocket sized compact camera that makes high quality macro shots possible. The camera acts as a tool for converting the material into images and by choosing specific details and angles of view I want to highlight certain aspects.

 # Natural light

Direct light - sun light direct
Indirect light - sun light indirect

 # Artificial light

Direct light - spotlight direct
Indirect light - spotlight indirect, Soft-box
Integrated light - LED light

ISO 250 f/2,8 1/60

Natural light tests

 # Direct and indirect lighting

The first light tests were situated outdoors in a natural environment. I tried to capture sunny and cloudy light atmospheres with different backgrounds and camera settings. In the following the short listed photos get described.

*Photo **# 1.1** shows the material in direct sun light with a shadow created by a tree branch. The darker areas merge the artificial material with the natural environment, whereas the light areas makes the plastic pop out, colour-wise and material-wise.*

*The close-up photo **# 1.2** was created while direct sun light shines on the material. In addition water drops are on the surface, which create a sparkling effect because the water and the material are reflecting the sun light.*

*Photo **# 1.3** shows the material embedded in grass and due to the frontal perspective it is possible to look through the gaps and see the green blades of grass in the background and foreground. The direct light setting makes the layers of plastic clearly visible.*

*With photo **# 1.4** I aimed at the backside of the material against the direct light source. However one can see through the layers of plastic bags and recognize bright light. The contrast of colours is lower and therefore the material is not as easy readable.*

*With photo **# 1.5** I introduced an artificial material, which is tin foil. It acts similar to a mirror but the plastic material gets blurred instead and only a touch of colour is visible.*

*Photo **# 1.6** was created with indirect lighting and hereby I wanted to break the orthogonal point of view by tilting the camera and creating a diagonal image of the material. The colour hues are muted but the plastic layers are still clear to identify.*

*Photo **# 1.7** was taken with long exposure time and moving the camera in the direction of the layers in order to emphasise the linearity of the material and to create motion. With this method a lively image is created where foreground and background blur together.*

*Photo **# 1.8** was taken with direct light and it shows the material placed directly on the grass, which makes the gaps appear black. The plastic membranes seem very bright and are standing out of the natural setting.*

*Photo **# 1.9** was taken with the material placed on a mirror. It shows the natural surrounding and colours that are less intense.*

 # 1.1 ISO 500 f/11 1/200

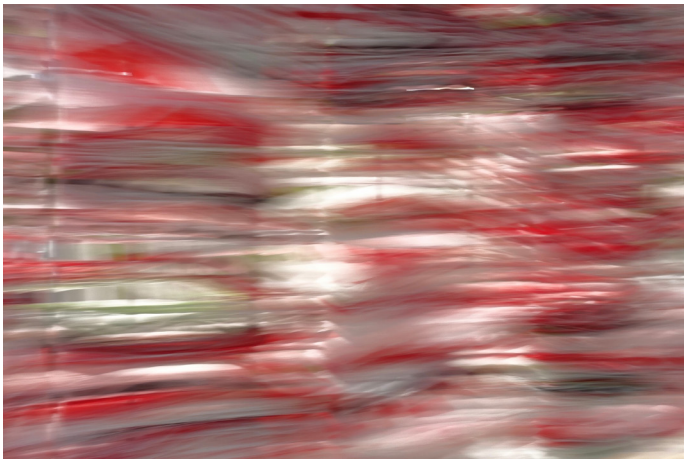
 # 1.2 ISO 125 f/4 1/1600

 # 1.3 ISO 125 f/5 1/640

 # 1.4 ISO 125 f/5 1/160

 # 1.5 ISO 125 f/4 1/1600

 # 1.6 ISO 125 f/3,5 1/320



 # 1.7 ISO 125 f/11 1/4

 # 1.8 ISO 125 f/5 1/1000

 # 1.9 ISO 125 f/4 1/2000

Artificial light tests

 # Direct and indirect lighting

The next light tests were situated in the photo studio with an artificial light set-up. I used two or one soft boxes, that are diffusing light evenly in an indirect way. Plus for some tests I added a spotlight, that distributes a direct light ray.

*Photo **# 2.1** shows the system from further away being completely without context. Therefore all the attention gets drawn to the material itself. The photo is created with direct light, however I aimed the camera at the indirect light effects on the backside because it shows the potential of light that bounces in-between the layers and it sort of creates an illumination from the inside.*

*For comparison photo **# 2.2** shows the side where direct lighting hits the surface and the material appears clear and accentuated with hard shadows in-between the layers. If direct light is only coming from one side, it puts the focus there and accentuates the edges of the material that appear almost white.*

*Photo **# 2.3** was created with indirect light and high ISO. Therefore the material appears very bright and flat since minor shadows are created. The artificial characteristic of the material gets enhanced. Plus the picture shows how the linearity of the layers can get disturbed by wavy parts.*

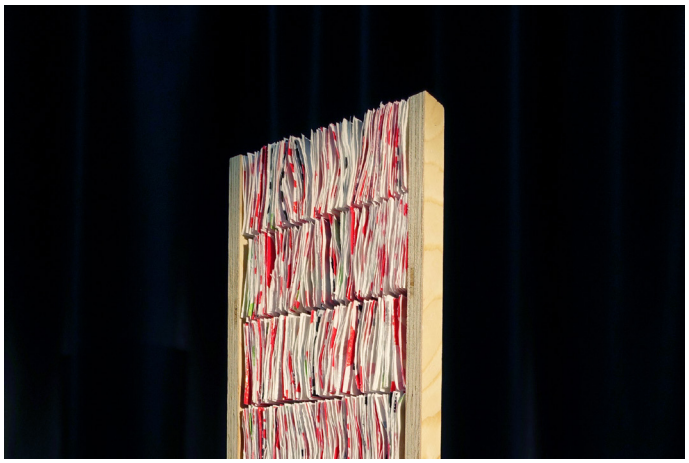
*Photo **# 2.4** was created with direct light and again the backside is shown, where the indirect light play gets visible. I wanted to make a close-up shot in order to catch the atmospheric illumination.*

*With photo **# 2.5** I want to illustrate the surface of the material, created with a combination of direct and indirect lighting. This creates a very lively and tactile experience since the contrast is high, which results in three dimensionality.*

*Photo **# 2.6** shows the complete system immersed in blue light. I created this effect by using a spotlight with a blue, transparent foil in front. The real colours disappear and get replaced by blue shades of colour. This creates a dramatic experience of the material.*

*Photo **# 2.7** is a representation of the whole wall element and it was created with direct light. The camera captures the backside in order to show the quality of the material that gets illuminated inside. It almost resembles glass elements.*

 # 2.1 ISO 160 f/2,8 1/160

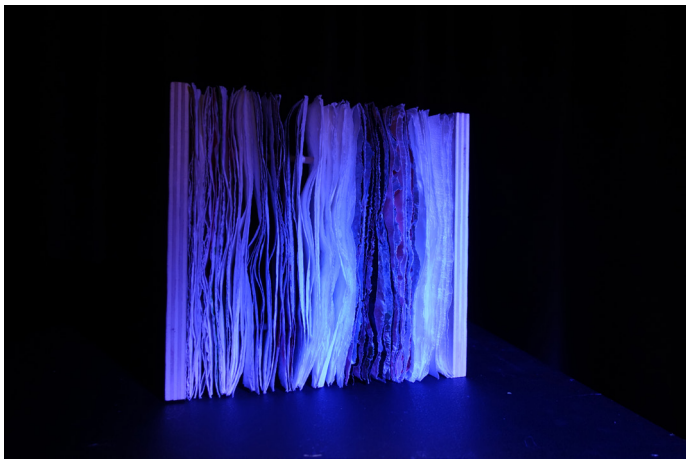


 # 2.2 ISO 250 f/2,8 1/400

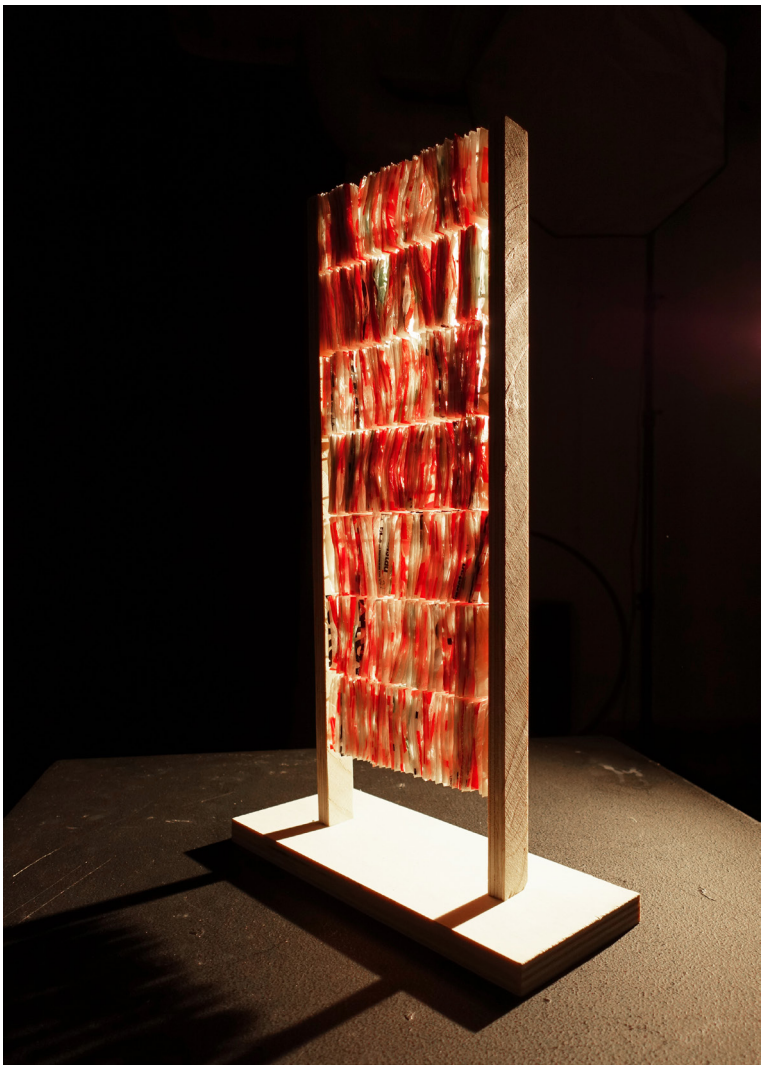
 # 2.3 ISO 1250 f/5 1/40

 # 2.4 ISO 160 f/2,8 1/25

 # 2.5 ISO 250 f/2,8 1/250



 # 2.6 ISO 400 f/2,8 1/15



 # 2.7 ISO 500 f/2,8 1/400

Artificial lighting

 # Integrated lighting

An additional part of the light tests was to integrate an artificial light source in the material. I decided to use LED sticks instead of wood or metal sticks. The quality of this specific system is that it has 2 in 1 functions. It is not only the structural element in order to hold the plastic in place but also a lighting element.

*Photo **# 3.1** is showing the complete system, where integrated lighting is the only light source. Not all parts get illuminated because the LED light does not reach all areas.*

*The close-up shot **# 3.2** shows that the light is the dominating feature however it follows the course of the layers. For instance here the light becomes wavy - so the light distribution is characterised by the layered material.*

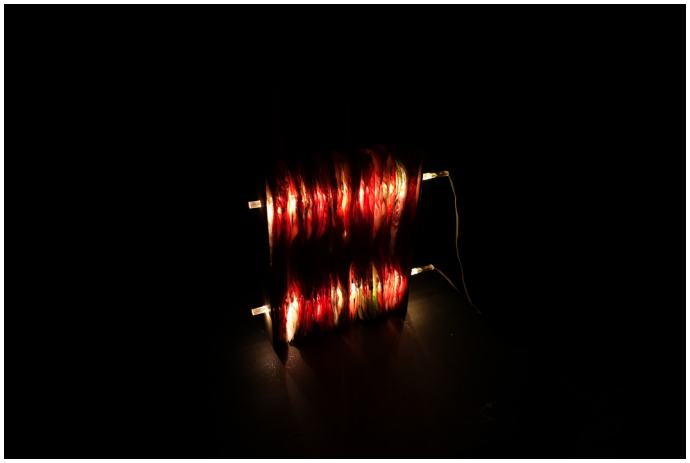
*For photo **# 3.3** I additionally turned on one soft box in order to lower the contrast of light and dark areas. Therefore the actual material of plastic bag membranes get recognizable.*

*Photo **# 3.4** shows that depending on the density of the layers the LED gets visible or not. The LEDs are white or yellowish in the centre but they start to adapt the colour of the material, where they are hidden behind the material.*

*Photo **# 3.5** illustrates that the light spreads gradually out towards where the intensity decreases (it is about 8 cm wide) and at the same time it follows the layers of the material, so it becomes almost a parallel light.*

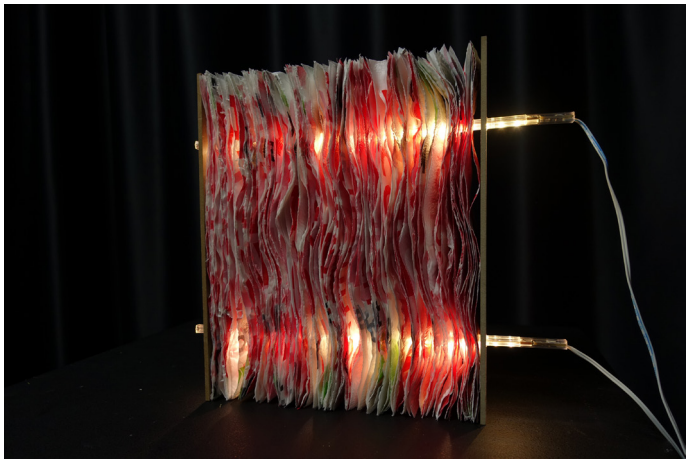
*With photo **# 3.6** I want to point out how strong the light reflections and the colours are, even though the original plastic bag has white as its dominating colour. In addition the material gets a glossy appearance.*

*Photo **# 3.7** is taken from distance and it shows the direction of the linear light sticks and that they are orthogonal to the layered plastic bags, against their direction. From far away the material has therefore stripes of light incorporated.*

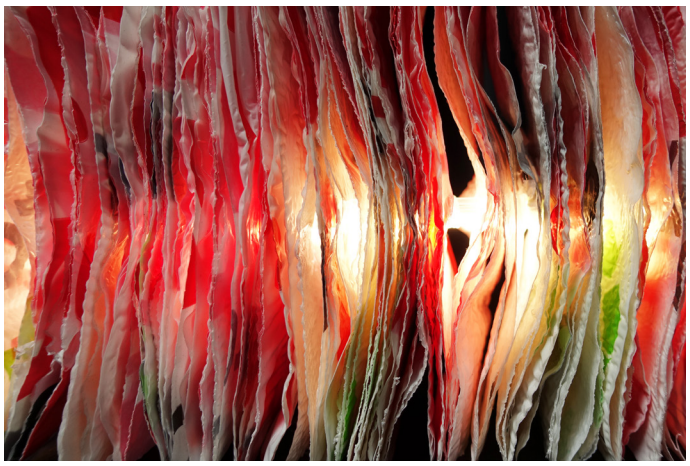


 # 3.1 ISO 400 f/2,8 1/100

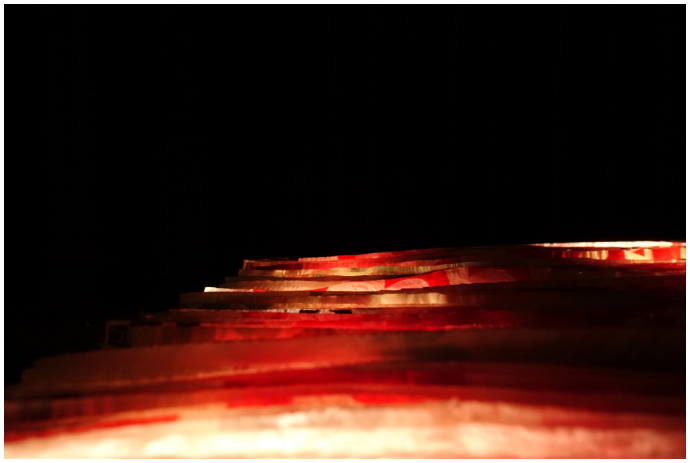
 # 3.2 ISO 1250 f/5 1/50



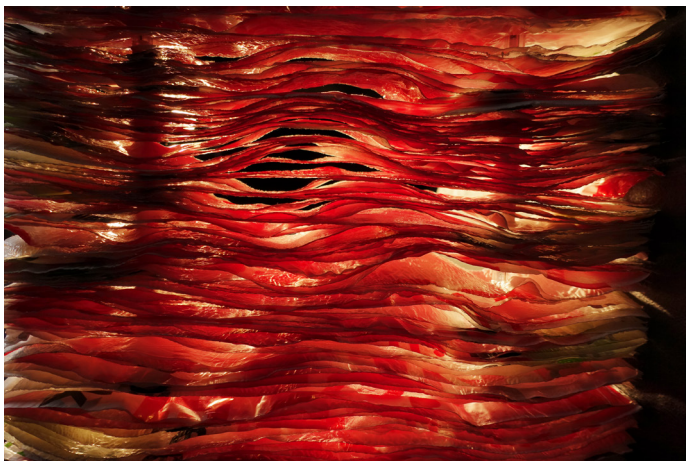
 # 3.3 ISO 160 f/2,8 1/80



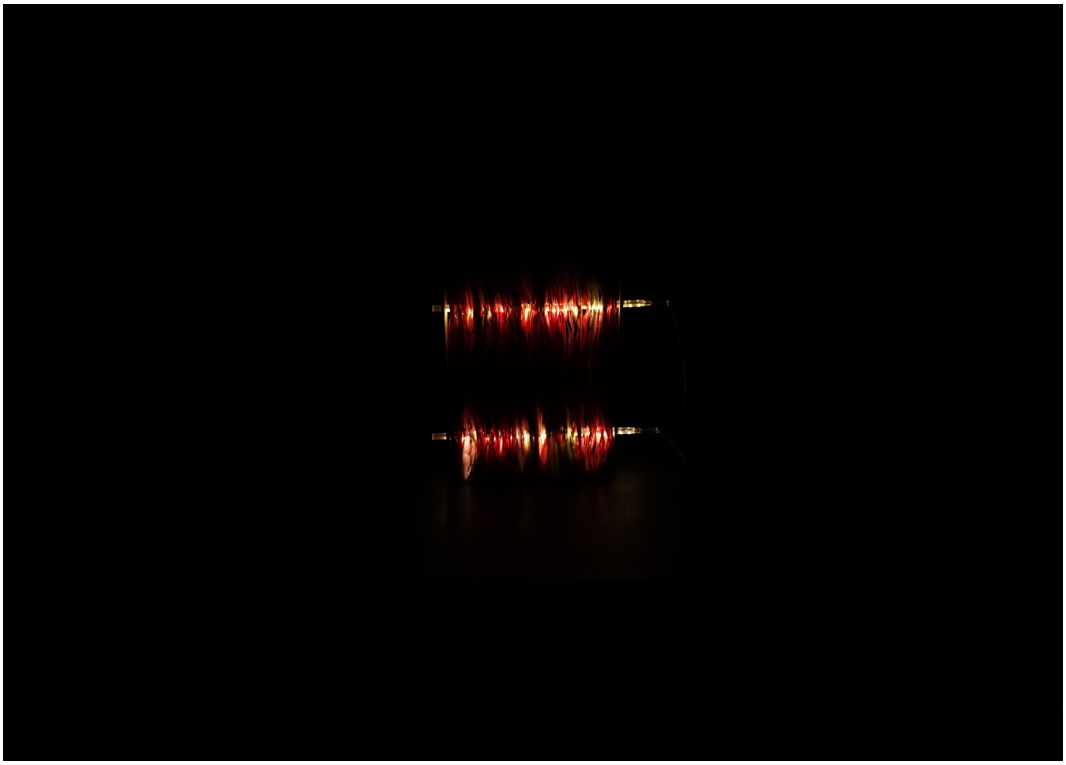
 # 3.4 ISO 160 f/2,8 1/80



 # 3.5 ISO 1250 f/5 1/40



 # 3.6 ISO 160 f/2,8 1/250



 # 3.7 ISO 400 f/2,8 1/640

Conclusion

The natural light tests made clear that indirect sunlight blurs the layers and the structure behind and the material tends to camouflage with the environment. Thus the layers are not easily recognisable because of the lower contrast. Natural indirect light creates therefore a more one dimensional experience, whereas natural direct light shows off the potential of the material. Direct lighting creates clear shadows of the material and every single layer is visible. The areas of bigger gaps between the layers are greyish and blurred the deeper they get. However the dark areas also accentuate depth of the material and show the three dimensionality of the material. In addition I think it is interesting when an artificial material has a natural setting since it does not match and sticks out, colour-wise and material-wise. So it clearly becomes a foreign material in nature. Plus it is also a juxtaposition of geometries, where the linear, parallel plastic layers meet the organic shaped surroundings.

Regarding artificial lighting I observed that artificial direct lighting creates sharp shadows and highlights and puts the focus on the material, which increases the level of detailing. For instance traces of the heating process get visible and the artificial aspect of plastic gets emphasised even more. Whereas artificial indirect lighting makes the material look smoother or more natural because brightness and contrast is lower. The indirect light setting illuminates also the surrounding areas, where the material is situated. Integrated LED light makes the edges appear darker and the inner part lighter. Logically the light situation is inverted. With this method dark areas are dominating since it is only LED lights. In addition direct lighting accentuates the colour of the material and creates almost a mystical experience of the material.

After testing the material with different light settings, I realized that light influences the experience of materials effectively in manifold ways. For instance it determines the areas of focus, it changes the appearance and it creates atmospheric gestures. Therefore materials can hardly be regarded without considering light, since they work hand in hand. This way of looking at plastics changed definitely my general approach to materials, where light is an active part of the material's expression.

During the course of the process I narrowed down the scope of finding various gestures within the method of layering plastic membranes. Finally I focused on finding specific plastic gestures that are creating experiences of the material situated around appreciation, beauty and preciousness. Therefore I consider the light tests as important since they exemplify that the material is not flat, one dimensional and static, instead it has multiple facets that change depending on the light situation and outer influences such as manipulations. In addition the translucency of the material and reflections caused by light bring the material to another level.

ISO 250 f/2,8 1/400

Reflection

This thesis is a material investigation in recycled plastic bags. Through material experiments methods of using the material could be tested and through photographic documentation crucial moments could be captured. Hereby I could also train my eye on how to look closely at materials in general.

The intention was to bring the atypical material concerning the field of architecture to a new setting where disposed matter in the form of planar plastics gets a new purpose. Over time I realised that there are many ways using recycled plastic bags and that I needed to restrict the methods in order to reach my goal of finding gestures of value and beauty.

With my work I did not try to solve the issue of plastic pollution however it is an attempt to rethink our attitude towards waste materials and to shed new light on recycled plastic bags in particular. Waste materials are having possibilities that we too often neglect and time has come to see usefulness but also beauty in them.

I worked with the method of building physical models and taking photographs of them. In that way I created numerous methods, that I needed to narrow down. Therefore the camera acted as a tool for evaluating the created material and putting the focus on the most interesting aspects. The photographs are likewise images that show the beautiful side of recycled plastic bags.

It is important to mention that my intentions and goals with the thesis changed during the course of the project since I discovered possibilities and new ways that I could not predict in beforehand. This is also an indicator that my thesis is rather a work of research than a design project.

The chapter of possible applications as a wall filling material is kept very small since my main focus is the material itself. Nevertheless during my presentations discussions were triggered around the material as part of buildings. Therefore this aspect could have been developed further within a broader time frame.

In addition I want to stress the importance testing the method of using recycled plastic bags under the influence of light. It helped me in recognizing the full potential of the material and I realised what significant effect light has on matter and in the further on architecture. Thus I want to bring this interplay of light and materials to future projects.

Finally I want to conclude with my main intention of finding preciousness and beauty in waste materials. I managed to treat, arrange and display recycled plastic bags in a careful but unconventional way, that can be also applied to other materials. In terms of material abundance this aspect of my thesis is highly relevant. And in terms of being an architect the endeavour to not only find usefulness but also appreciation and beauty in materials is meaningful.

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