WAREHOUSES AND LOGISTICS BUILDINGS

KJETIL MIKAEL SORTLAND

DIPLOMA THESIS
FALL 2020

ABSTRACT

All over the globe there is a common problem of visual contamination: large, ugly logistics buildings that dominates the areas outside our cities. They are not built to be seen, yet they cannot be overlooked. In my diploma thesis, I will find out why they look like they do, and explore different possibilities on how to improve the overall visual impact.

MY OBESERVATION

My journey with logistics buildings started during a photography project, where I was documenting peri-urban areas outside Oslo. By spending time in these kind of areas it is hard to ignore these huge structures that visually defines vast spaces and becomes almost territorial. It was a new experience for me to actually walk amongst these giants and experience them at close range. I have of course seen buildings like this many times before while traveling past them by either car or train. But to actually standing still and being present in this area made me realize how much of an impact they actually have.

Logistics buildings is primarily built to function, and not to be seen. I believe this is affecting the way we observe them. I think we learn to ignore them overtime, and we somehow forgive their appearance because they are not built for us to enjoy anyways. But by taking a closer look it raised the question in me if they really have to look this way.

I must admit there is something intriguing about these buildings as well. There is also beauty in this specialized typology when you're considering the how well they work. In all its unworthiness as a piece of architecture it represents a building that perfectly solves it's functions. It's a product of ruthless priorities and hard competition to perform in a very specific way. It represents the possibility for someone to have all the space they need to do their job fast and effectively. To be able to concentrate on what is important, and not be bothered by irrelevant things. It is an abstract form of beauty, much like a mathematician can rejoice over a beautiful equation.

The logistics building of Sport 1 Gruppen AS at Kløfta outside Oslo.

THE TYPOLOGY OF LOGISTICS BUILDINGS

As the name implies, this typology is all about logistics. Moving large amounts of commodities in an effective and organized fashion. Storages, warehouses, factories and production facilities all need to be able to receive, handle and send out again their goods fast and care free.

There is also a need for large interior spaces to store, produce or reorganize the goods. It is based on the logic to gather all in one place in order to save time and money. Normally the interior spaces is organized in only one level, due to the use of forklifts and trucks.

Within this typology you also find buildings like data centers where the purpose it is just to provide shelter from the environment in an easy way as possible. So the intention or qualities of these spaces is not necessarily for humans, but for objects.

Logistics buildings are usually located outside major cities near to vital infrastructure. Relatively close to where the employees live, to potential customers or other businesses. They also often need quite large building sites. These are of course cheaper and more available outside the cities. Most businesses depend on trucks to bring their goods back and forth so it is most effective to be close to a major road. In Oslo you would typically find these buildings in the peri-urban belt in the rural outskirts of the city. Local authorities usually set aside specific areas for this kind of typology and cluster them together.

Cushman & Wakefield warehouse outside Prague, Czech Republic. A typical situation for this typology.

The Hydroscand construction site at Lindeberg near Oslo. August 2019

WHY DO THEY LOOK AS THEY DO?

The simple answer to this question is money. The business that finds itself in need of a logistics buildings, want to solve this problem as fast, cheap and simple as possible. The focus is on the operational performance of the building and little resources are spend on outward appearance. Short building time, low material cost and little maintenance is crucial. As Le Corbusier would have put it; It is a machine for working in, and not much more than that. With the economy as the strongest determining factor standard solutions that can be mass produced are normally chosen. The load bearing structure is usually a post and lintel system made of steel or concrete that has a very good structure/space ratio. Also the structure usually allows for expansion at a later stage. I will try to develop this topic more in detail later in this paper as I am exploring the different building aspects.

IMPORTANCE

Whether we like them or not, logistics buildings are an important typology for the modern society. Postal services, online stores, distribution centers and factories all use these kinds of buildings. It is a vital cog in the clockwork of our way of living. Sadly most of these buildings are treated as a “back of house” typology, something that is hidden away behind a more representative building. But what used to be a small shed in the backyard, is now a very large industrialized building.

Because this typology is built with a focus on internal functions and overall operational quality, and because they are normally tucked away outside the cities, we usually accept the lack of care when it comes to the outside appearance. They are left to be just sheds. The problem is that they are far from being a little building that can be hidden away. Because of their enormous size they play a vital role in visually defining a place. Also they are usually very noticeable as a foreign object in a charming and farmland setting.

As mentioned earlier logistics buildings are normally situated outside larger cities near vital infrastructure. This means a high number of people are passing by and observing these buildings every day. We all have experienced arriving at a new city by plane and taking a cab from the airport to the city itself. It is really like entering via the backyard, having to pass large areas of neglected spaces. This is also true for Oslo. When traveling by car or train through a landscape in high speed the distances becomes smaller and we relate to larger areas as one place. Thus the impact of a logistics building lasts longer then if we were to observe them from a stationary position. This “backyard“ is a also a lot of people’s home. Both in suburban and peri-urban context people have to relate to these buildings in their everyday life; looking at them from their kitchen window and driving past them on their way to work. The visual aspect of a logistics building is in other words very important and cannot be neglected.

Because of their specific functions and tight budgets, we may have to accept that they are built as sheds. But we need to stop treating them as an unimportant typology and also take the outside more seriously. Maybe it is time to leave the virtue of honesty and start decorating these sheds, accepting fake ornaments and put on some makeup?

DVS Solutions AS at Kløfta outside Oslo

VENTURI AND DECORATED SHED

During this semester I read the book “Learning from Las Vegas” by Robert Venturi and Denise Scott Brown[1]. I though would it be interesting to read a survey of a type of place and architecture that have been neglected or created for commercial reasons and not for architects. In the second part of his book, Venturi talks about “ducks” and “sheds” which I find to be very interesting in the discussion of logistics buildings. It seems that these types of buildings are very eligible to be treated as “sheds” and not “ducks”. A “shed” is a is a simple volume with classical elements that also act as symbols, instead “ducks” where the building shape and the materials depicts its function. Venturi things it better to to simply decorate a building instead of building a decoration.

Examining Caruso St John’s contribution to the Venice Biennale in 2018 I got interested in the classical principles of the urban façade. In the exhibition “The facade is the window to the soul of architecture” the firm stresses the importance of façades and their responsibility to make a positive contribution to the public realm[2]. They should have the capacity to emotionally affect people even thou they are just passing by. Caruso St John is showing this by displaying a series of buildings following classical rules. A heavy ground floor relating to the street and pedestrians, a defined mid- section and a lightweight and often recessed top. The façade has a certain hierarchy and depth to it and one all loads is being carried all the way down to the foundation. These principles are often totally neglected in the façades of logistics buildings. A smaller building can more easily abandon classical rules and be an abstract object. But I think very large volumes needs to have something that is recognizable in order for humans to relate to them in a good way.

I dislike when a building appears to be an object that can be picked up in one piece and be put down somewhere else and still be intact. It appears as a much smaller object that has a totally different material quality then a building many times it size. It is like when picking up a toy car, it would still maintain its form even though you only held it by the side mirror. If you turned it upside down it would not collapse on itself. Many new buildings look like they have the same quality. I want to create a building that looks like it has been build! Much like a urban façade where something is resting on top of something, and the whole structure would collapse if you moved it or turned it upside down.

1 Venturi et al. 1977
2 Caruso 2018

Logistics buildings at Kløfta outside Oslo

CRITIQUE

In my opinion, logistics buildings are in general quite ugly. They are dead, dull and disruptive buildings that seldom gives anything back to the place they are situated. They are like boring TV commercial disrupting an exiting movie, a necessary evil. I would like to sum up my critique in the following points.

NEGLECTED EXTERIORS

There are made very little effort in caring for the outside appearance of these buildings. It is what goes on inside that is important, hence no concern is made for the outside. The efforts taken to beautify the facade is normally not helping.

BREAKING THE CONTINUITY OF A LANDSCAPE

Due to the size of the building itself, and the large flat area surrounding it, logistics buildings create a halt in the continuous flow of a landscape.

LACK OF HUMAN SCALE

Logistics buildings are created for heavy machinery and enormous volumes. There is left little thought for humans interacting with the building from the outside. Both the building itself and the surrounding area has no human scale, and therefor inhuman and alienating.

FOREGIN OBJECT

Logistics buildings often appears as a foreign object in the landscape. The problem is that they are not rooted. It does not relate to its surroundings in any way.

ANONYMITY

The “face” of the logistics building feels just dead and empty. There are normally no windows or other features to connect with or relate to. The buildings have no ”soul”. It is like talking to a person without a face or that has turned his back to you.

The food production facilities of Alimenta AS at Lindeberg.

Various facades from warehouses and logistics buildning at Kløfta.

WHY ONLY THE FACADE?

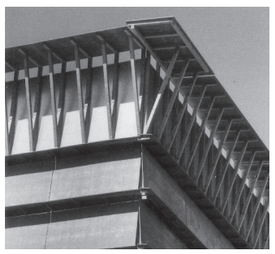
In my program(pre-diploma) I set out to investigate how to give form to large warehouses and logistics buildings through an holistic approach, working with all aspects that makes up such a building. My intention was to question and potentially redesign everything: program, internal spaces, structure and facade etc. I wanted to propose a new way of designing logistics buildings as an alternative to the existing practice. The overall aim of my work was to discuss large volumes and their form in relations to a place.

Then, in the early stages of my diploma semester, I soon came to realize that it was both more interesting and more relevant to work with the outside alone, treating the diploma as a facade study only. As I studied this typology I noticed that the established system behind logistics buildings is already highly specialized and fine-tuned. It would simply not be very rewarding to try to re-define a totally new type of logistics buildings. Perhaps it was also too optimistic unrealistic to develop a competing proposal within the span of only one semester.

The outside appearance of logistics buildings is not much affected by what type of load bearing structure one chooses to use. Prefabricated concrete elements, steel portal frames or just a regular steel system with H-columns and trusses, all ends up looking the same way on the outside- a rectangular box. Even those buildings who has a more unconventional shape, or has chosen a more interesting facade material end up using a standard constructive system. In other words, the overall shape and appearance is a conscious decision, and not merely a result of the limits of a constructive system.

Based on these realizations I decided to accept the interior system of logistics buildings as it is. Moving forward in my thesis I will also use an already established structural system for these type of spaces. My focus will be on the outside appearance so I will leave warehouses and logistics buildings to be just standard sheds on the inside.

Ricola Krauterzentrum by Herzog & de Meuron, 2014. Rammed earth façade and prefabricated concrete loadbearing structure.



Ricola Storage Building by Herzog & de Meuron, 1987. The beautiful façade of fiber cement sheets covers a standard sandwich element wall.

Factory Building on the Vitra Campus by SANAA, 2012. Circular plan, but with a load bearing system following an orthogonal grid.

LIMITATION OF THESIS

Logistics buildings are a wide topic in itself and is a typology that is found all over the world. Their shape, size and appearance is of course highly dependent on their use, which can be almost anything. In order to not end up discussing the world of logistical buildings in only general terms, I have chosen to work with a specific situation as a case study. I will study the newly built facilities of Hydroscand AS and use their building as a template for my own work.

I chose this company in this site because it was an entirely new project and would therefore be quite up-to-date when it comes to technology and solutions. In addition also the lot is recognized as a premium industrial property and very sought after in the real estate market. It is a good example of a typical situation one could find outside Oslo. Hydroscand is not the only company establishing themselves in this area. But I chose them because they have a very straightforward program and requirements for the building, and thus works well as a general example. I will elaborate on this later on. I will use their needs and requirements as a standard or reference to my own findings when relevant.

Hydroscand building at Lindeberg..

A PRESENTATION OF HYDROSCAND

Hydroscand AS is a leading provider of services and solutions for industrial hoses and pipes. The company was established in 1969 and is now a multi-national corporation. The company has specialized in services for hoses and fluid components, OEM solutions, machines for hose production, pipe bending and other related services.

The company has several storages and dealers in Norway. The facility that I will use as a case study is their newly built national headquarters and main storage located at Lindeberg outside Oslo on the way to the airport. They had outgrown their old facilities at Grorud in Oslo, and where in need of a building that could serve their logistical needs better. They chose the site at Lindberg because it was closer to where their employees already were living and provided good exposure from the highway. The facility holds 45 employees and contains an office department, storage with a production area and a showroom.

The industrial real estate company ”BULK Infrastructure” bought the site at Lindeberg back in 2016. After securing deals with potential buyers they developed the site and built the buildings according to the company’s needs and requirements. ”BULK Infrastructure” also build the buildings using their own system called ”Bulk Module”. This is a modular warehouse design optimized for pallet storage, pallet racking, and handling. ”Bulk Infrastructure” has different arrangements with the companies using their buildings, but most of them rent the facilities for a period for 10-12 years with a deal to buy them later on. ”Bulk Infrastructure” is also in charge of maintaining the property.

An employee working inside the new facilities of Hydroscand at Lindeberg.

ECONOMY

As mentioned earlier the cost in a logistics building project is a strong determining factor. In my thesis I will conduct various cost estimates as a way to better understand what the economical consequences is for potential design choices. I have based my calculations on a Norwegian cost database called ”Norsk Prisbok”[1]. It is a comprehensive resource for contractors with updated price information for all kinds of materials and services related to the building industry. I will use this resource as consistent as possible to establish a good foundation for comparison in my investigations.

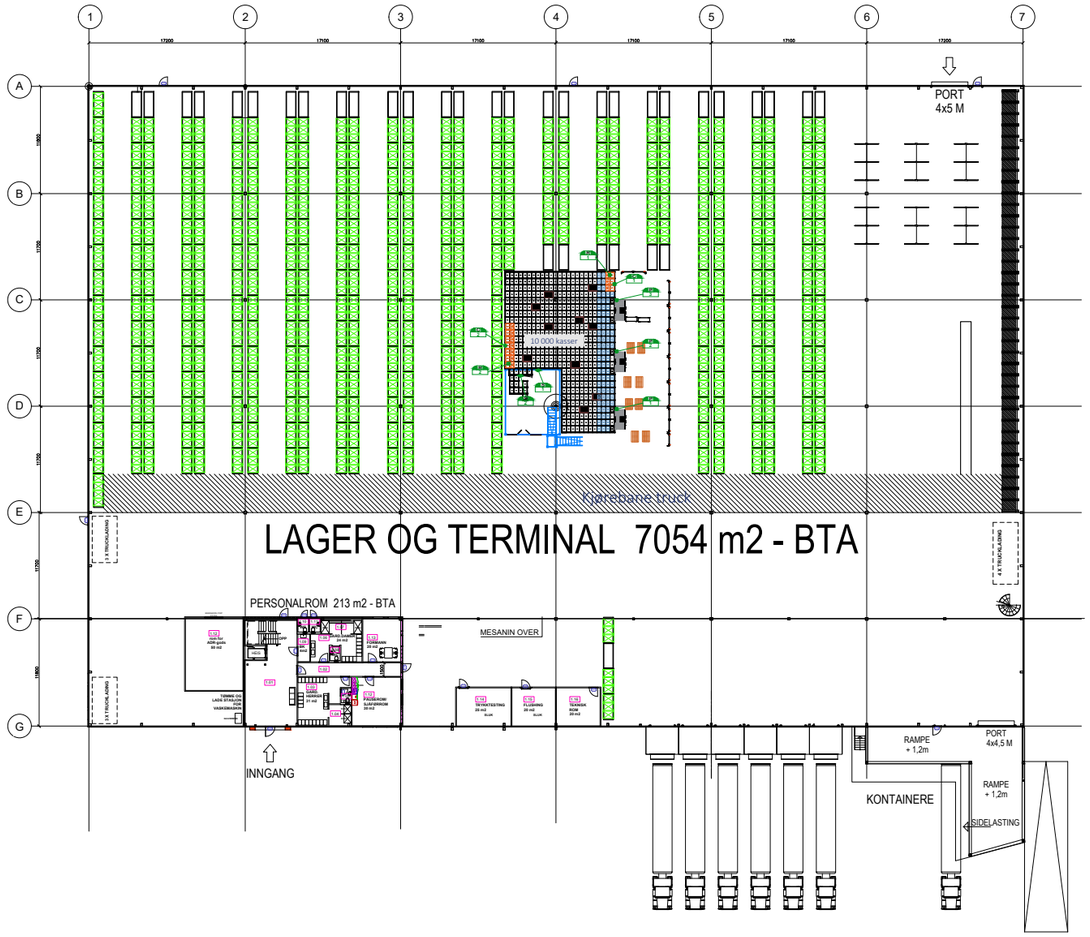
In the textbox below I have calculated the cost of the Hydroscand building and included cost estimates for other building types.

ACCOUNT	Cost/m2	Pris
Shared costs	1,122	9469680
Building	6166	52041040
VVS-installations	1,345	11351800
Electrical	567	4785480
Telecommunications	227	1915880
Other installations	36	303840
Outdoor	713	6017720
General costs	814	6870160
VAT	2747	23184680
Expected additions	400	3376000
Uncertainty provision	287	2422280
TOTALT	14,424	121738560

COST COMPARISON OF OTHER BUILDING TYPES

Hydroscand .....14,424 /m²
Shopping malls. 1 level, without basement. 24 709/m²
Office building. 5000 m².....40 187/m²
School building. 2 levels.....37 871/m²

1 Norconsult 2020



Existing plan of the Hydroscand building. The plan is developed by Bulk Eiendom and YSA Design.

PROGRAM

Storage: 6000m² (height 11,7m)
- Heated, min +12°.
- Rows of storage racks, depth 1200mm.
- 3000mm between aisles.

Additional storage: 600m²

Terminal: 800m²

Driver’s area: 200m²

Office area: 600m²

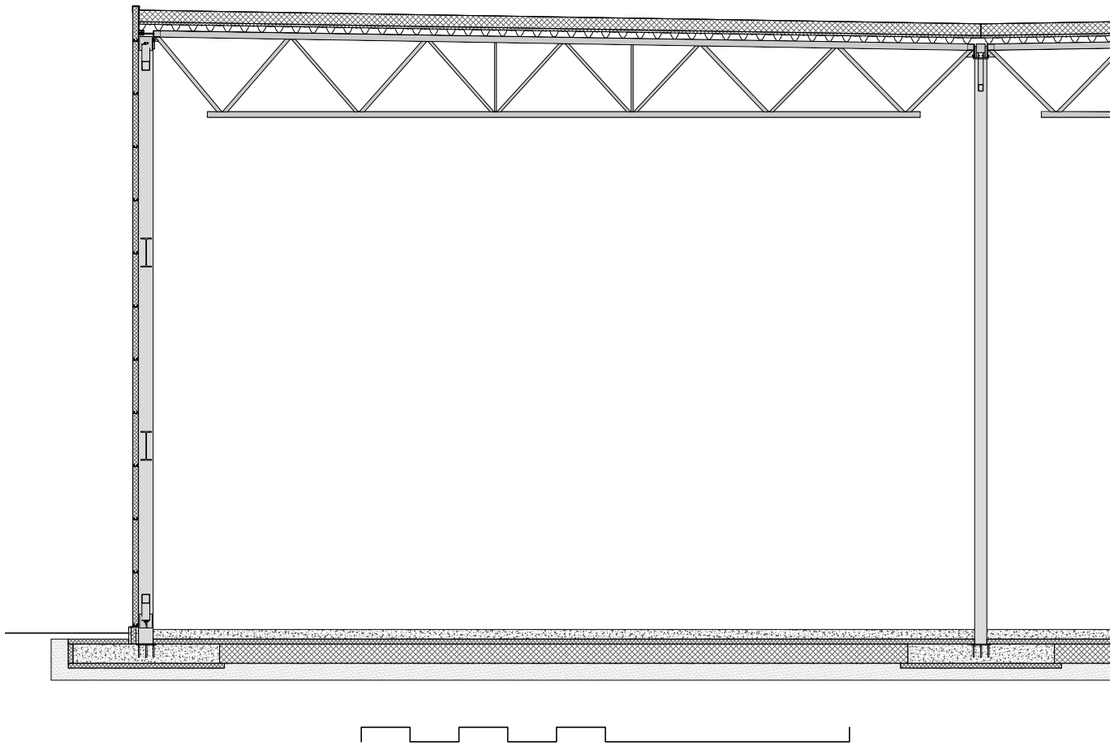
Parking: 650m²

THE BULK SYSTEM

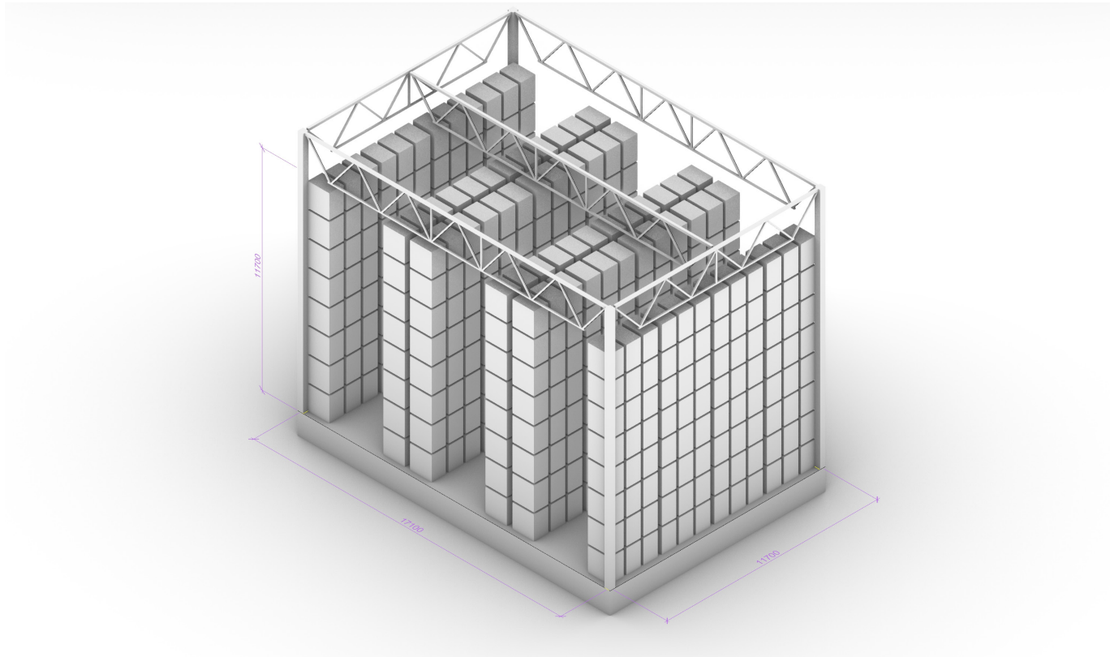
As mentioned earlier ”Bulk Infrastructure” has developed their own logistics building design aimed for the Scandinavian market. ”Bulk Module” is a modular system optimized for pallet storage, pallet racking and handling using forklifts. The grid system is very flexible and can be expanded in all directions. This system is what I am basing my research on and using as a template for my own work. I find it to be well designed for its purposes and it is a good example of a standard solution used in logistical buildings.

The ”Bulk Module” is a steel post and lintel system based on a 11,7 x 17,1 meters grid. The columns are square hollow sections supporting the main trusses with a pinned connection. Horizontal stiffening is provided by vertical cross bracings on the end walls. The trusses are slightly inclined having a taller cross-section at one of the sides to provide water drainage for the roof. Trapezoidal steel plates forms the roof slab and supports the roof insulation layer.

Construction time is about 6 month for a building similar in size to the Hydroscand facilities. All elements are transported using trucks and are ready to assemble upon arrival. Individual concrete foundations for each column is casted on site before the floor slab is poured. Many steel building manufacturers uses prefab foundations instead for the columns, which seams to be a more effective solution.



Section of the Bulk Module



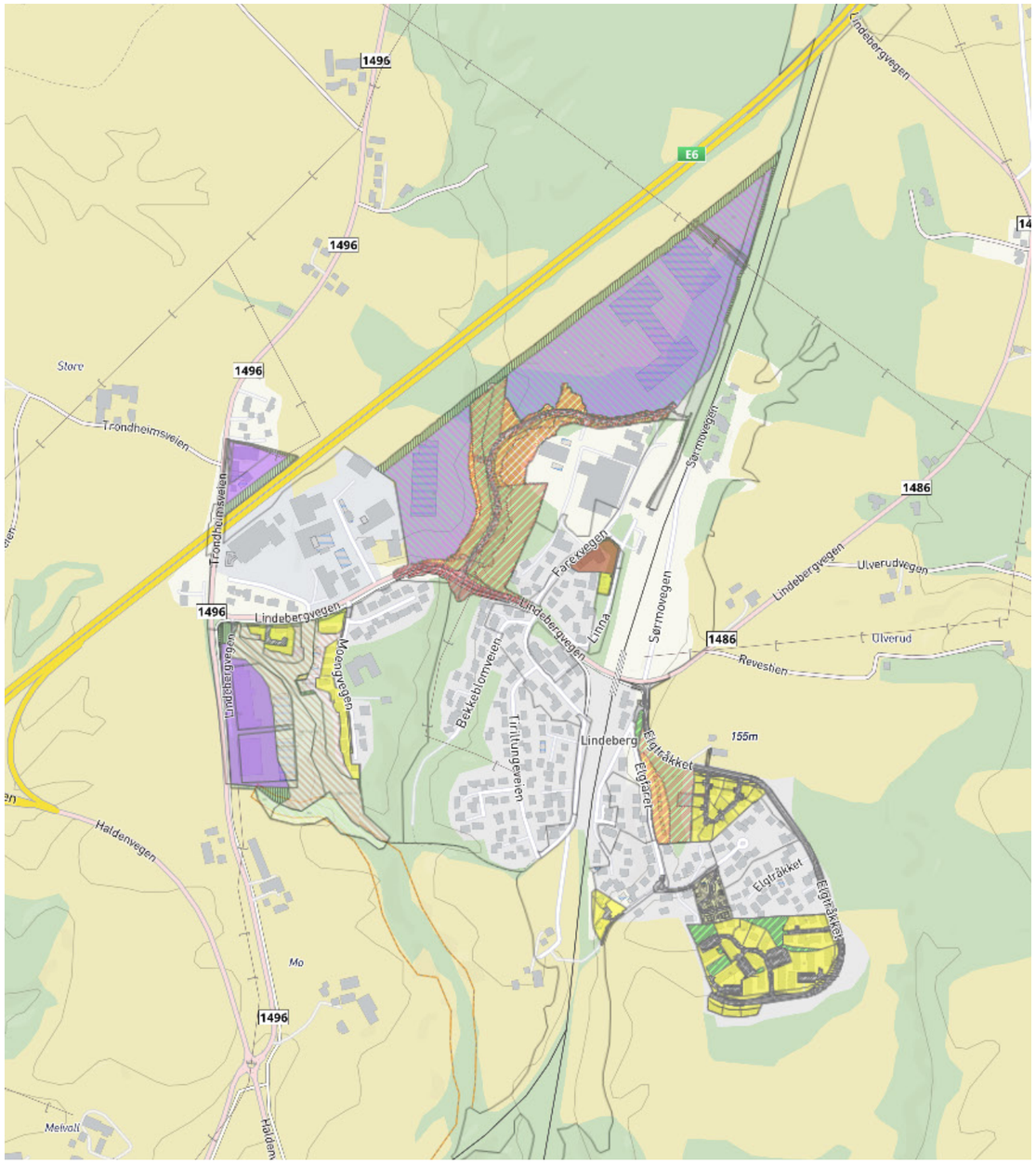
Akso of the Bulk Module

ZONING PLAN

The local municipal authorities issued a zoning plan in 2013 regulating the industrial area at Lindeberg. By comparing the more sentimental beautification measures applied on Hydroscand and the zoning plan, it is clear they have only just fulfilled the requirements and nothing more. To begin with the zoning plan gives some measurable limitations on the use of the site. One can build no closer than 100 meters from the highway and 30 meters from the railroad. There is a height limitation of 14 meters and the footprint needs to be between 45-55% of the property size.

Further, the plan specifies that buildings situated in the same area, or alongside the same road, needs to be in a harmonic state towards each other. This should be reflected in shape, roof angle and materials. When choosing materials and colors, the visual effect should be considered both in short and long range. Reflecting surfaces should be avoided except for windows. Large façade surfaces should be of a color that doesn't stick out when seen from a long distance. All facilities should be of a high architectural standard and that the relationship between neighboring buildings and the landscape should have a unified architectonic expression. There are also specific regulations on design and placement of company logos on the buildings, but I don't think it is necessary go into further detail.

Regarding the visual appearance of the buildings for an industrial area, the current zoning plan is quite vague. The requirements refer only to generic architectonic qualities that all new projects should take into consideration anyways. I would also argue that, looking at the result, the municipality doesn't follow up their requirements thoroughly. But I do find it interesting that they mention the importance of the effect a building has when observed from different distances.



Zoning plan of 2013, Sørum Municipality

Lindeberg

INTRODUCITON TO THE MAIN INVESTIGATIONS

In order to answer my research questions I have divided the different components, or aspects, of what makes ap the totality of the façade, and I have studied them individually. These are the categories:

- Volume
- Positioning
- Composition of façade
- Additions
- Lights
- Materials
- Surface

In each category I will examine today's status, existing practices, and explore alternative solutions and improvements.
I recognize that the act of designing a building is not like at mathematical equation, but is more about nuances, sensuality and the entirety. The total result of a building is so much more that its individual components.

THREE SCALES

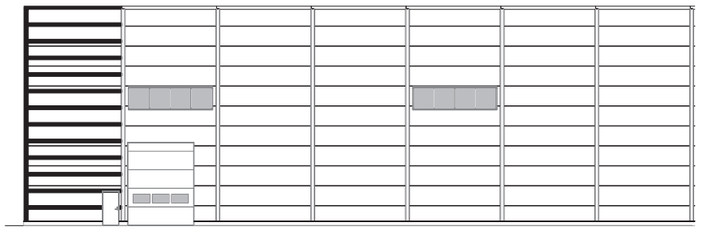
Because of the large size of the logistics buildings, and because of the situation we normally find them in, I find it relevant to work with a set of three scales. A building is radically differently perceived at a distance of 10 meters than when you are looking at it from 1000 meters.

CLOSE RANGE: 0-30 meters distance from building. This is a understanding of the building when entering on foot. One is not able to see the entire building at once. One will notice the texture, tectonics and space in the façade.

MID RANGE: 50-100 meters. Typiccaly when observing a building from a car or truck. One relates to the building as one, and one is aware of pattern, rhythm and over all composition of façade.

LONG RANGE: 700-1000 meters. One is perceiving the building in relationship to the landscape. Much of the details in the façade is not visible. Colors are faded but one is aware of main shape.

Close range



Mid range

Long range

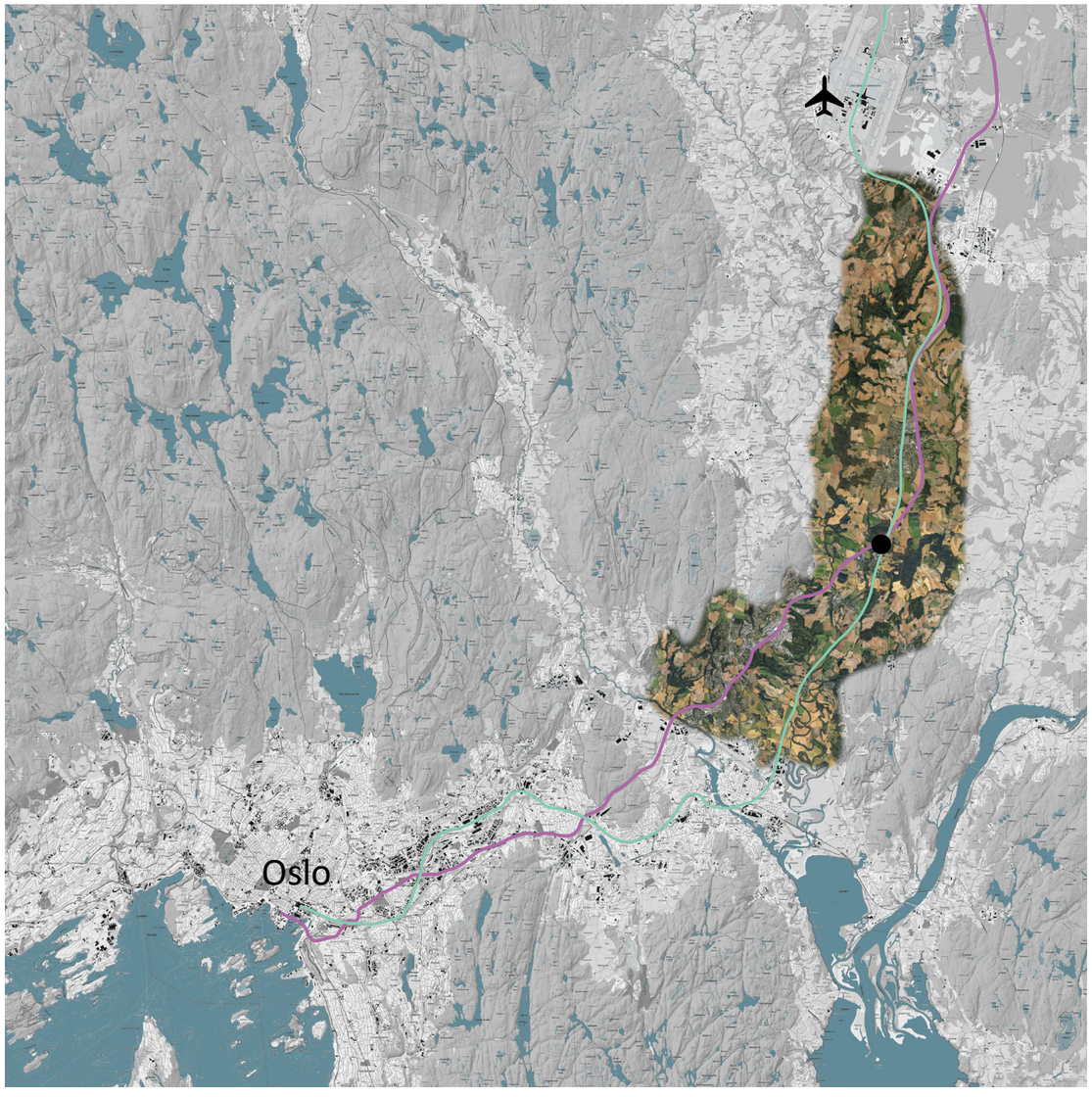
DEFINITION OF PLACE

After riding the train back and forth between Oslo and the airport a couple of times, I became aware of the geographical limitations of the landscape. When observing from a train the context is defined by similarities, or rhythm, type of nature, topography and building typology. Traveling in high speed allows seeing things in a bigger context and thus connecting larger areas as one. I think it is therefore necessary to evaluate a building in relations to a larger area than what is normally done.

One cannot observe a building only in relation to the nearby houses or the town it is located in. One must keep in mind that a passenger on a train (or in a car) will experience a building in connection with a much larger area.

The southernmost point of ”my place” is right after Lillestrøm when traveling from Oslo. The railroad is passing under a small bridge at 59°58’18.7”N 11°04’08.2”E. There it feels like one has passed in to another area, from the urban context of Oslo and Lillestrøm to a more rural and open landscape. This “chapter” continues until one approaches the international airport at 60°08’56.9”N 11°08’55.5”E. Visually the landscape is more or less the same after one has passed the airport as well, but I think the airport acts as a mental transition point.

The area between Lillestrøm and Oslo airport is categorized by rolling hills with grain fields and patches of forest arranged in an organic pattern. The area was formed during the last ice age when a huge amount of loose sediments was dispatched as the ice retracted. Rivers have cut out narrow V-shaped valleys that makes a clear contrast to the overall terrain. This is a rich farmland and has been cultivated for several centuries.



The defined area

CONCLUSION

Finally, I will summarize the most important findings I have made during my research, and then show with a specific project how the Hydroscand building could have been design in order to achieve a more attractive visual impression.

Exisisting situation

INVESTIGATIONS

Investigation 1: VOLUME

In the beginning of this semester, I decided to spend some time traveling between Oslo and the international Airport. It was through this exercise I learned what would be a natural limitation of the landscape. I used train as a means of transportation since this allowed me to sit in quiet and observe without being distracted by traffic. One could also do this exercise by car, observing the site from the highway, which is approximately the same distance from the Hydroscand property. I traveled numerous times past the site in both directions documenting my findings through photos and taking notes.

A building, even an logistical building, is not of course only experienced in motion and can therefore not only be design for an moving audience. Butt still, most of us experience these buildings while traveling past them either by car or train. In 2019, the Hydroscand site was passed about 60 million times. That is 11 times the population of Norway.

Traveling through a landscape in high speed seems to make both buildings and nature appear smaller. It resembles the experience of looking of a small model where one can see everything in simultaneously. Movement is almost braking the barrier of 3-dimensionality, where we can see the front and back at the same time. The eye also recognizes an overall rhythm more easily in the objects that is seen in motion. It is something beautiful and interesting of seeing a building form several angels in a short amount of time.

In this first investigation, studied how different volumes appeared in movement. The investigation consisted of filming wooden models using a rig that would give similar results every time. The models where built up using birch blocks representing the BULK module in a 1:500 scale (11,7 x 17,1 x 14 meters). I have chosen 10 test to illustrate what I have found. Please see the video named “1.Volume” which is included in my diploma submission.

Installation used for testing objects in movement

People passing the site in 2019 (one person could be counted several times)[1]:

By train: 15 486 211
By car: 44 367 210
TOTAL: 60 000 000

The sites exposure from train measured in time:

Local train: 28.9 sec.
Express train: 15.3 sec.

The sites exposure from car measured in time (speed limit: 100 km/h)

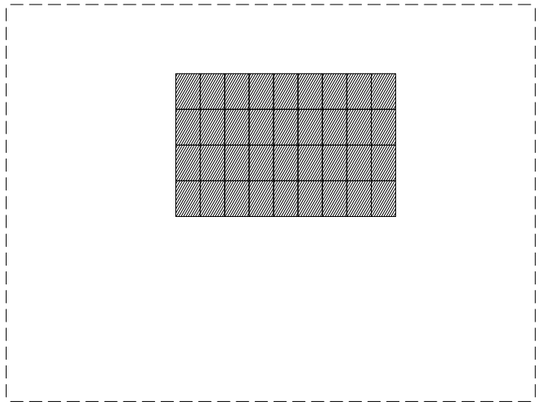
South to north: 46.2 sec.
North to south: 39,6 sec.

1 Statistics Norway 2020

TEST 1 - RECTANGLE

36 moduels
Footprint: 7 200 m^2
Façade area: 4864 m2

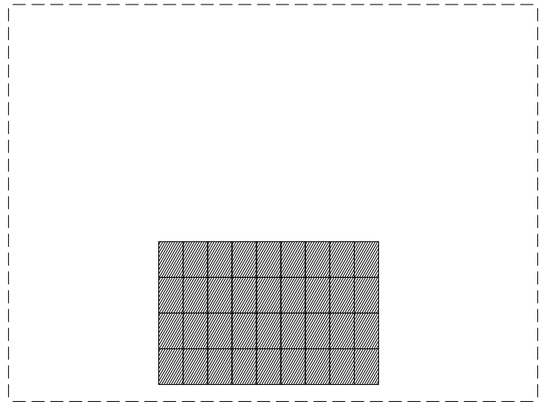
The first test acts as a reference for the other tests. It is the same size and shape as the present Hydroscand building and is positioned approximately at the same distance from the highway. The predictable straight box-shape is in itself not so interesting. It could in some situations make the building stand out as an object in a positive way, and even enhance monumentally. But in this context, and because it is so large, it is mostly boring.



TEST 2 - RECTANGLE CLOSE

36 moduels
Footprint: 7 200 m^2
Façade area: 4864 m2

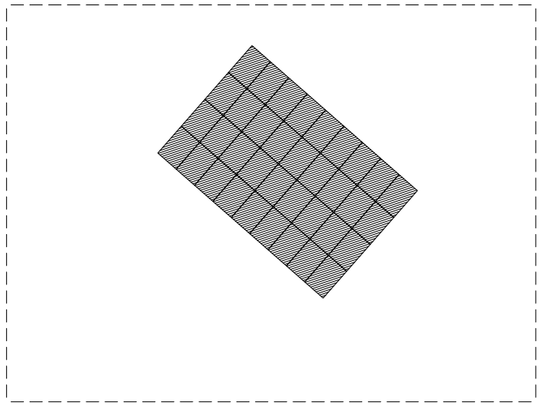
It gets even worse when the box is positioned very close to the road and the passer-by only see a endless façade and can't relate to the building as a whole. It is a dull experience that removes the observer away from the bigger context of the landscape. It is better for a building not to have a facade parallel with the direction of movement, like seen it test 3.



TEST 3 - RECTANGLE DIAGONAL

36 moduels
Footprint: 7 200 m^2
Façade area: 4864 m^2

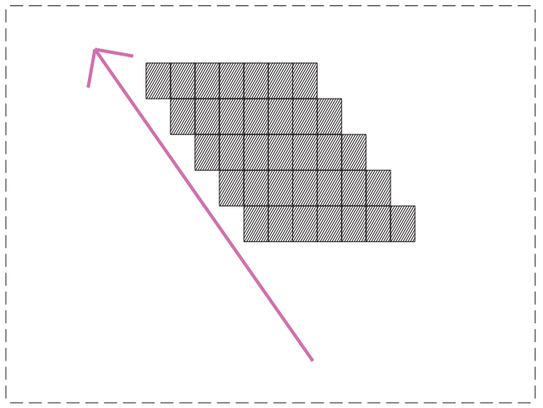
If the building is placed diagonally in relations to the road the observer gets more impression of depth and that improves the experience.



TEST 7 - PARALLELOGRAM

36 modules
Footprint: 7 200 m^2
Façade area: 5998 m^2 - 23,3% increase

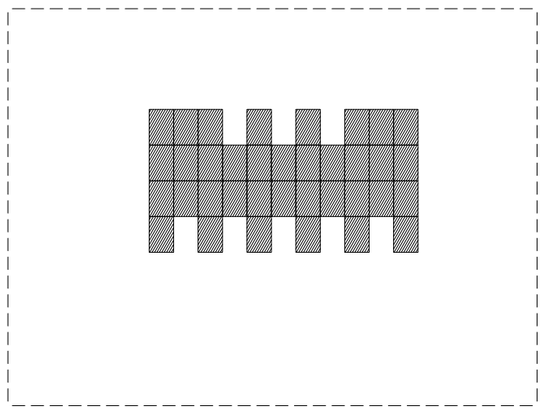
The parallelogram works well as a shape in movement because it changes character through time. The moment observer is aligned parallel to the "inclined" side, the rhythm of the steps is revealed. This is pleasing to the eye and gives the observer a feeling of participation in the "shaping" of the building.



TEST 5 - RIBBED

36 modules
Footprint: 7 200 m^2
Façade area: 9349 m^2 - 92,2% increase

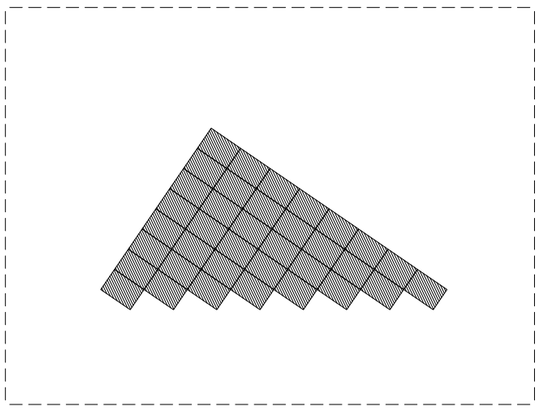
The ribbed façade reveals different parts of the façade as the observer passes the building. The hidden bays is only seen when positioned directly in front of the building. This creates an acceptation in the observers and potentially a surprise if the bays is of a different character than what is seen from the side of the building.



TEST 31 - TRIANGLE

36 modules
Footprint: 7 200 m^2
Façade area: 6440 m^2 - 32,4 % increase

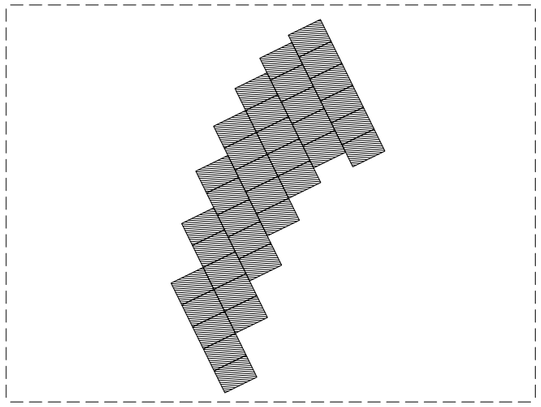
The triangular façade works much the same as the ribbed façade, but the difference is that there is no "front side". In this way, you only see half of the building when approaching from the side. There is a potential for the building to have two different qualities depending on which side it is observed.

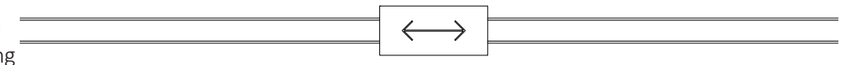


TEST 16- CURVED

36 modules
Footprint: 7 200 m^2
Façade area: 7501 m^2 - 54,2% increase

This is the test I feel works best in terms of being pleasing to the eye. The increasing rhythm of the curved sides creates an interesting situation. Internally, the standard module is divided in three sections (see fig. xx). This is reflected in the outside rhythm as every step is 1/3 of a module bigger than the previous. Observing this shape in movement creates a sequence of appearing or disappearing corners. There is also a strong variation in depth because of the way the building is placed on site. This creates a richer experience of the volume.

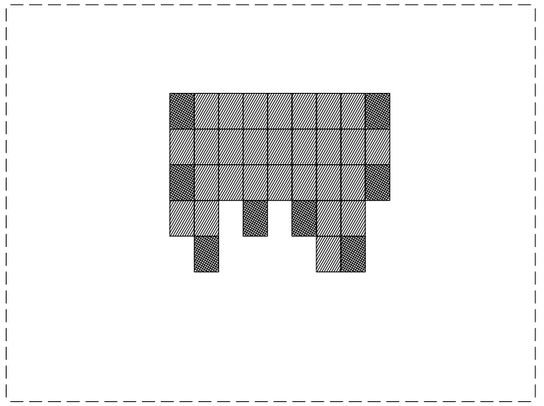


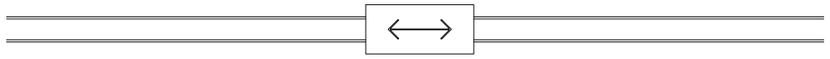


TEST 22 - DISTORTED

36 modules
Footprint: 7 200 m^2
Façade area: 6778 m^2 - 39,4 % increase

A seemingly random shape with no particular system or rhythm. Compared to the regular box this is still an improvement in being an more interesting object to pass by. The variation of depth in the façade gives the eye something to explore and focus on. The same goes for the colors, giving an opportunity for the observer to recognize a pattern.

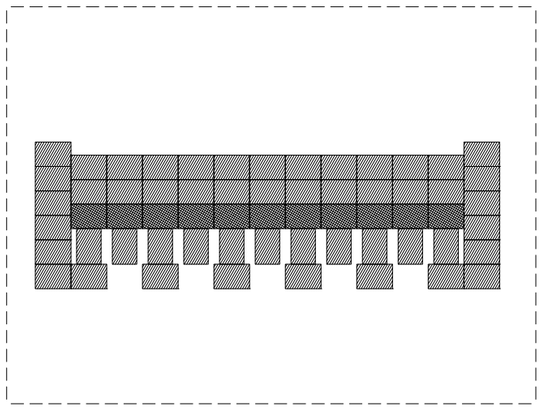


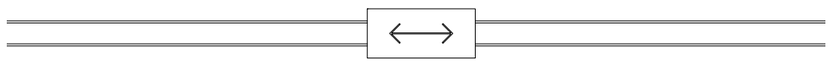


TEST 35 - ARRAY

62 moduels

This test is not directly comparable to the reference test since it has more modules. I included this as an example of a further exploration of the potential of a ribbed façade. The bays are more narrow and complex and thus giving a more rich or variated experience when passing by the building.

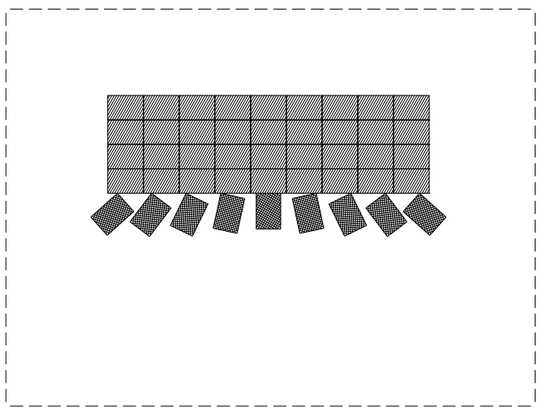


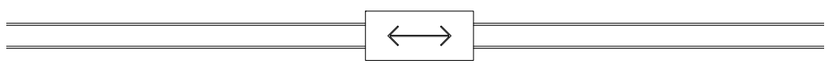


TEST 20 - STAR RIBBED

45 moduels

The star shaped façade works together with the anticipated movement of a passer-by. Each rib is directly positioned towards the observer at different times during the movement.





SUMMARY

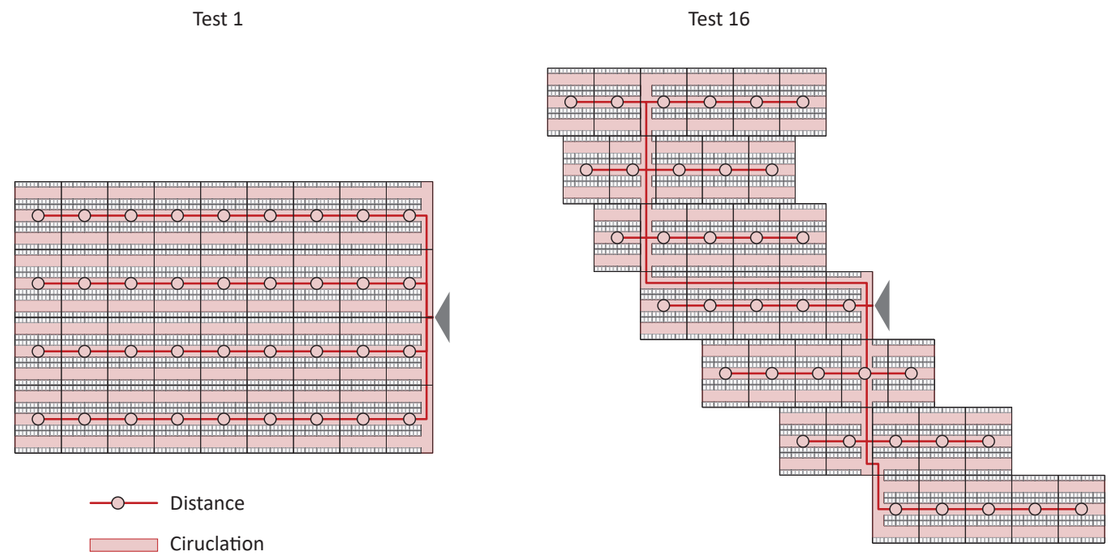
In this investigation I found that several shapes were interesting in terms of observation in movement. As mentioned earlier, test no. 16 is the shape that I found to be the most pleasing to the eye. The façade area of test 16 increased by 54,2 % when compared to test 1, the default shape. As shown in the table below a 54,2% increased façade surface area equals a 7,8% increase in the total building cost.

When altering the outside shape of a building, the interior spaces consequently change. I wanted to find out what this change meant for the internal efficiency in terms of storage capacity and circulation. By comparing the existing Hydroscand building (test 1) with test 16 I learned that the difference is actually not very big. The dimensions of the “Bulk Module” is designed for handling and storing standards pallets. So, by following the intended layout for the pallets racks, I calculated the area needed for circulation in both test no. 1 and no. 16. In order to estimate the efficiency of the circulation, I measured the distance from the center of each module to the “entrance” point, following the paths of the circulation area. The comparison shows that there is no difference of the area needed for circulation in the two “shapes”. But test no. 16 has a 5% increase in circulation length.

When only storing and handling pallets, the modular system proofs to be very flexible, and an alternative building shape does not cause any major decrease in efficiency. Of course, this does not apply to all warehouses and logistics buildings where production or large machines make it inappropriate to choose a shape other than a square.

Considering all the test results, I have learned that choosing a different building shape than the standard box significantly improves the experience for an observer in motion. And I found that a more unconventional shape is not necessarily less efficient internally. The only negative consequences is the extra cost due to the increased façade area.

As mentioned earlier, one of my critical points against logistics buildings, is that they very often poorly relate to the surrounding situation. They break the continuous flow of a landscape and does not relate to the terrain. One could argue that the extra cost of the increased façade is worth the opportunity to adapt a building to the existing topography so that the building would be more firmly situated in the place.

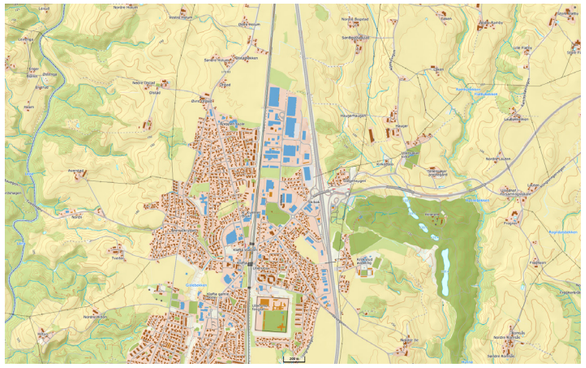


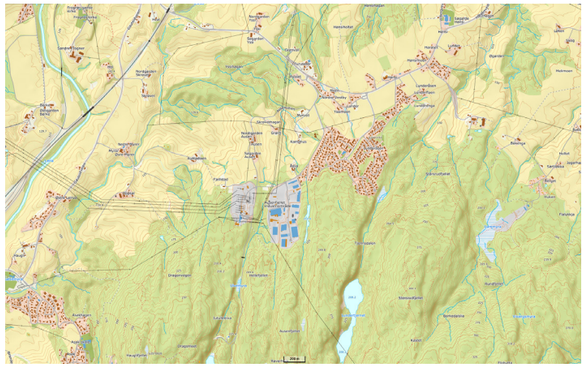
BUILDING TYPE	FASADE COST	% INCREASE	STRUCTURE COST	% INCREASE	TOTAL BUILDING COST	% INCREASE
TEST 1 - RECTANGLE	7 089 600		16 145 720		52 041 040	
TEST 16 - CURVED	10 941 163	54,2%	18 567 578	15%	56 125 461	7,8%

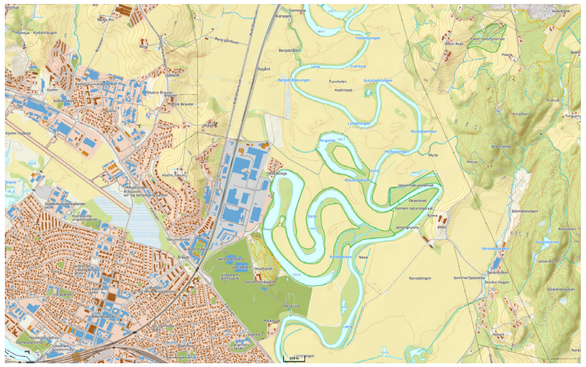
Investigation 2: POSITION

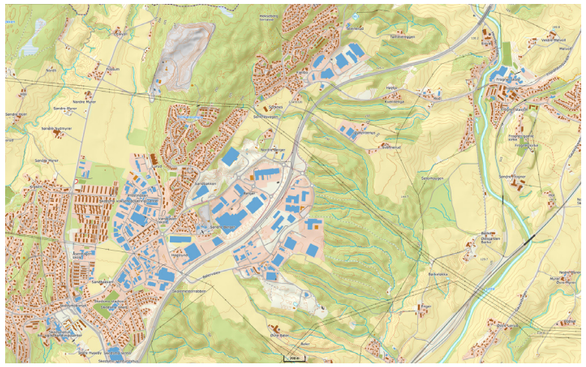
Industrial areas are often located outside the city where there is still space and where land prices are not so high. Logistics buildings are often located where there are already buildings from before or planned as an extension of existing industrial plots. It is important that the industrial sites have good communication to motorways as well as easy access to railways for workers / commuters.

Exisisting situation plan









Areas with logistics buildings outside Oslo

CRITIQUE OF CURRENT STATUS:

Unfortunately, logistics buildings are often located too close to highways. Those who travel on the road are sitting too close to long, boring facades. This has a disruptive effect as it takes the observer out of the landscape experience. The industrial plots should have been better regulated by the local authorities.

Normally when observing architecture, the spectator can choose his distance to the object, but car and train passengers are forced to follow a strict linear path which determines the distance to the object and the viewing angle. Therefore, it becomes even more important to position logistics buildings further away from the roads and the train rails than what is the norm today.

The “Hydroscand” plant is built in accordance to the existing, municipal zooning plan. The shape of the plot is determined by the municipality designating an area between the E6 highway and the railway which for noise reasons is not suitable for housing development.

One can criticize that the industrial area has been planned on top of an existing farming land, and in this way destroyed valuable topsoil. But this is an issue that falls outside of the scope of my diploma thesis. If you look at the rest of the Oslo area, you see that the industrial areas are intentionally located close to the main roads and transport systems since sending and receiving goods are of vital importance to logistics companies. In addition, it is important for many companies to expose their brand/logo to the people passing by on the road or on the railway. It seems that the zooning planners have sought to place the industrial areas where they are not in the way of housing development, but instead the industrial plots are used to shield residential areas from road noise.

The industrial site at Lindeberg

The building authorities have taken some successful steps, but there are also parts of the zoning plan that do not work so well. The industrial area “Hydroscand” is a part of is laid out in a small valley so that the building volumes do not break the horizon. The visual impact from the buildings on the landscape is limited to the valley. But on the other hand, the large volumes of the buildings and their clean shapes prevents the buildings from blending into the landscape. Seen from afar, the buildings appear as alien boxes. The zooning plan also set a minimum distance to the highway and the railroad. This is an important measure to minimize the negative effect I have criticized above when the travelers have their landscape experience interrupted by a long boring facade. Please see the attached video called “postioning.mp4”.

The buildings relate to the highway and are parallel to it. It creates a neat and orderly expression, but I would still argue that it is more pleasing to the eye if one can avoid an overly dominant wall of logistics buildings. Maybe rather twist the buildings so that there is much more depth in the experience?

The industrial area is pragmatically divided into smaller lots according to which company that is going to be established there. ”Bulk Eiendom” bought the entire property and then distributed smaller plots to each company according to their needs for space. The local municipality demanded that the plots should be utilized (buildup) between 45% and 55%.

Bestseller Logistics Centre North by C.F.Møller Architects

THE TESTS

I am investigating if the site allows alternative shapes and at the same time maintaining the operational functionality. Also, I want to investigate if other shapes can relate better to the terrain and improve the experience for by passers by car or train. All tests have the same number of building modules, parking lots and terminal area. The test is relating to the current site as it is.

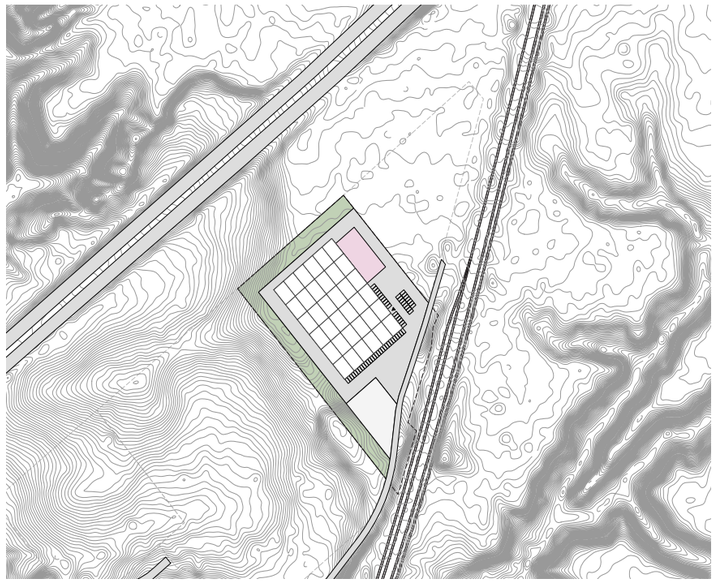
The site requirements are:

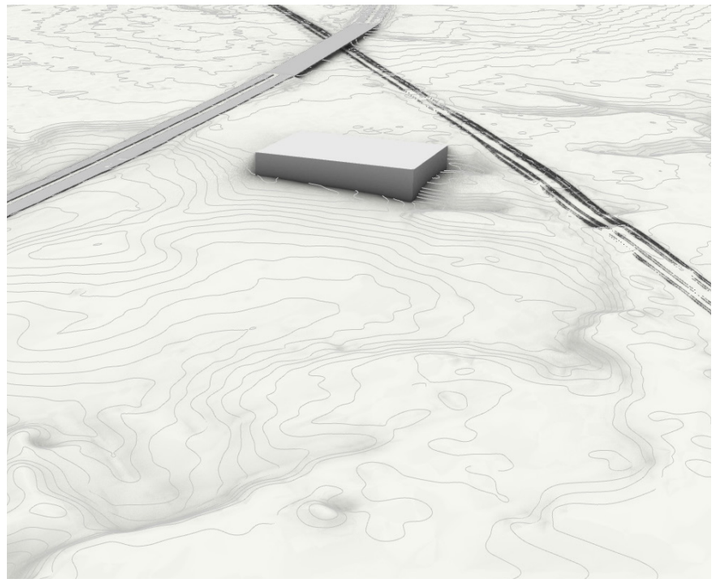
- Truck need to be able to drive around the building. This is to maintain an efficient traffic flow and avoid clog up if trucks.
- The terminal needs to be easily accessed from the road and allow maneuverability for big trucks.
- Space for 59 parking lots near to main entrance and maneuverability for cars.
- Main entrance close to access road
- Space for temporary storage of goods and machinery.

TEST 1

Gravel: 1676 m2 Grass: 4549 m2 Asphalt: 15155 m2

This situation is showing how the exciting Hydroscand building is situated on the lot. The rectangular shape is aligned with the direction of the perimeter, and sits perpendicular to the highway. The darker gray area around the building shows the paved surface for circulation, parking and storage. This position allows a green belt on the sides facing the highway that can potentially serve as a transitioning buffer.

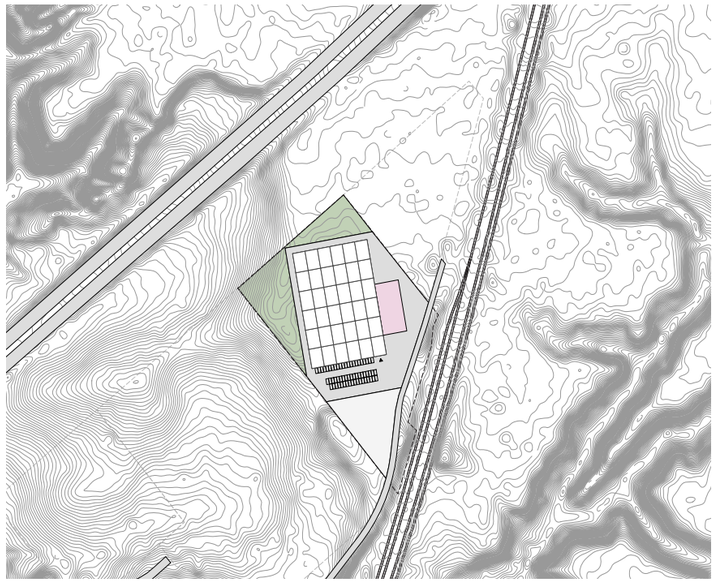


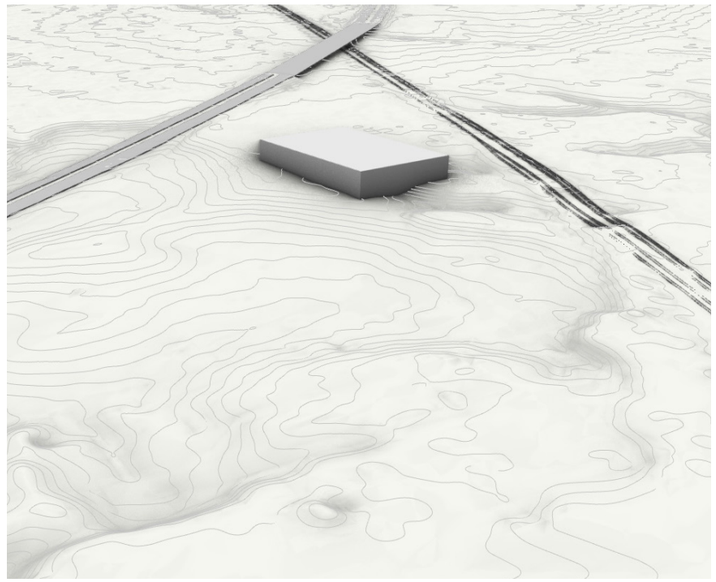


TEST 2

Gravel: 2652 m2 Grass:4379 m2 Asphalt: 14258 m2

This plan is showing the Hydroscand building in a rotated position in relation to the lot. The building is now more aligned with the contours of the sloping hill below the site. Both the highway and the railroad are now facing the corners of the building, rather than a parallel façade. As illustrated in the previous investigation on volumes, this can be an improved experience for the traveling observer. The rotated position also enables triangular spaces for the paved surface and green buffers. This can be beneficial in terms of turning radiuses for trucks and richer vegetation.

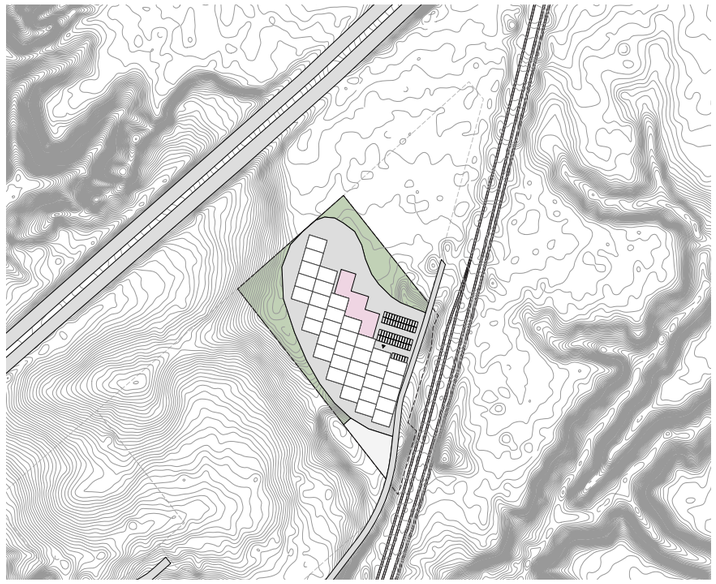


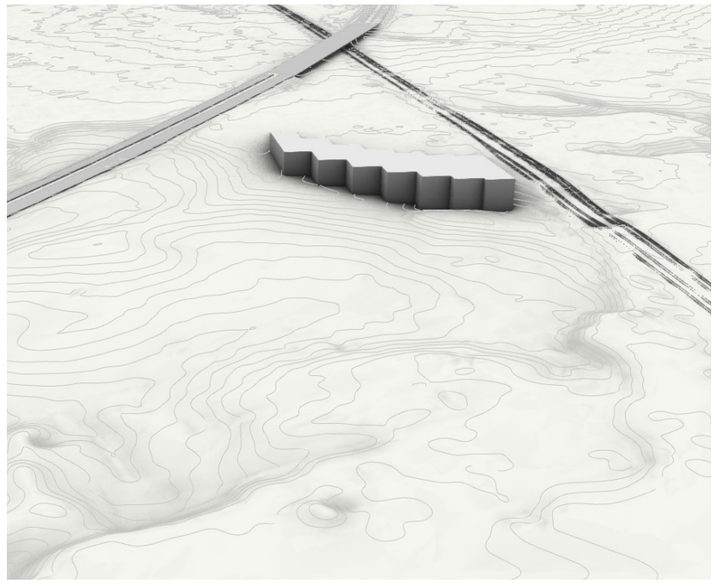


TEST 3

Gravel: 1019 m2 Grass: 4379 m2 Asphalt: 14258 m2

Plan 3 illustrates one of the volumes from the previous investigation, test no. 16, which is superimposed on the site. The building sits aligned with the curvature of the terrain and still meets all the operational criteria in this test. Due to the organic shape of the building, the paved surface can better adapt to the topography and thus blend more naturally with the surroundings. If one could accept the use of more unconventional building shapes one could design the general layout of the industrial area according to the terrain so that the overall building mass would actually relate to the topography.

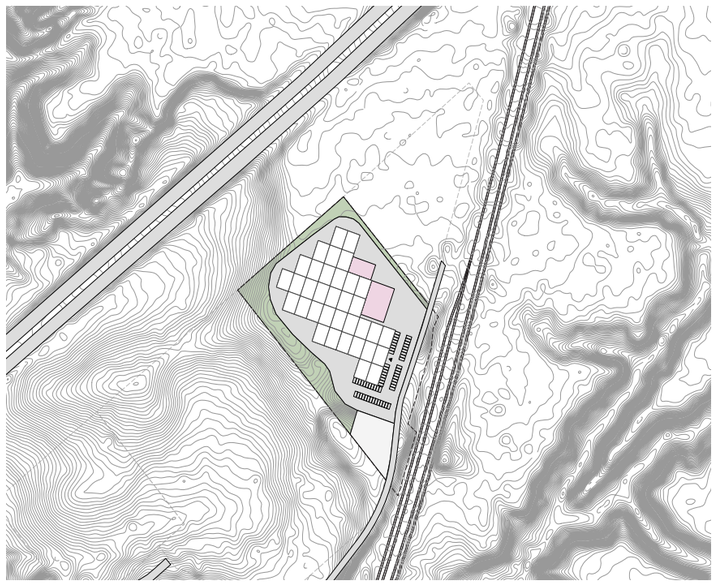


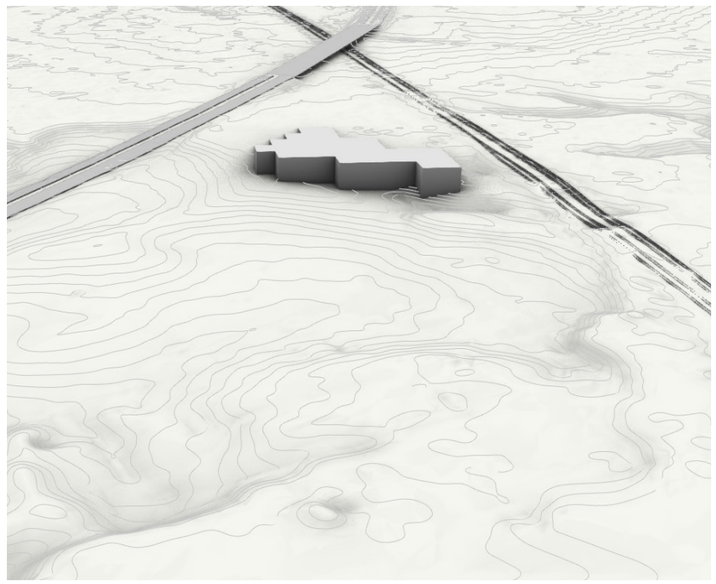


TEST 4

Gravel: 1019 m2 Grass: 5271 m2 Asphalt: 15081 m2

This plan is showing a volume where some of the principles learned from the volume investigation is applied together with trying to relate to both the sites limitations and terrain. The volume is working with rhythm of modules and variation in depth towards bypassers. All test criteria are met and the paved surface not as intrusive to the topography as the existing situation.





CONCLUSION:
What I have learned is that since the degree of utilization of the plot is as large as it is, it is limited what we can achieve by placing the building differently on the plot so that it becomes more adapted to the landscape. You simply cannot move so much on the building within the plot boundaries. Instead you might want to move the plot or its boundaries, but that would have been a matter for the municipality and the regulatory authorities as I have mentioned earlier.

Although the zooning/regulation made by the municipality makes a lot of sense, my investigations have shown a room for improvements. The plot allows to move the box and still have the main functions intact. The plot also allows more unconventional building forms, and this provides opportunities to construct a building that is better adapted to the terrain on site. On this specific plot, it is more suitable with a more elongated building that runs along with the elevations. In this way the building will be experienced as more site-specific and rooted in the situation.

A logistics building is dependent on having large flat areas available outside for maneuvering trucks and for intermediate storage of machinery and goods. Hence it is not desirable that the angles for trucks when crawling and starting and stopping at loading ramps, are too steep. Therefore, in any case one has to level out a larger area than the building itself occupies. But by adapting the building's shape to the surroundings, one will be able to reduce the terrain encroachment. Something that in return will reduce the development costs.

Investigation 3: COMPOSITION

The next investigation is about the composition of the facade. I have asked myself how can one arrange the facade in order to achieve the following goals: a)how to make façade more appealing? b) how to relate better to the landscape c) and how we can alter the impression of a rectangular shape? The facade of a logistics building is normally very long stretched – a form that is not necessarily a beautiful in itself. Especially if you take in to consideration the Golden Section. The ratio of the Golden Section is 1 to 1.618, but the ratio of the "Hydroscand" building has a ratio of 1 to 16. And that is not even one of the longest buildings out there.

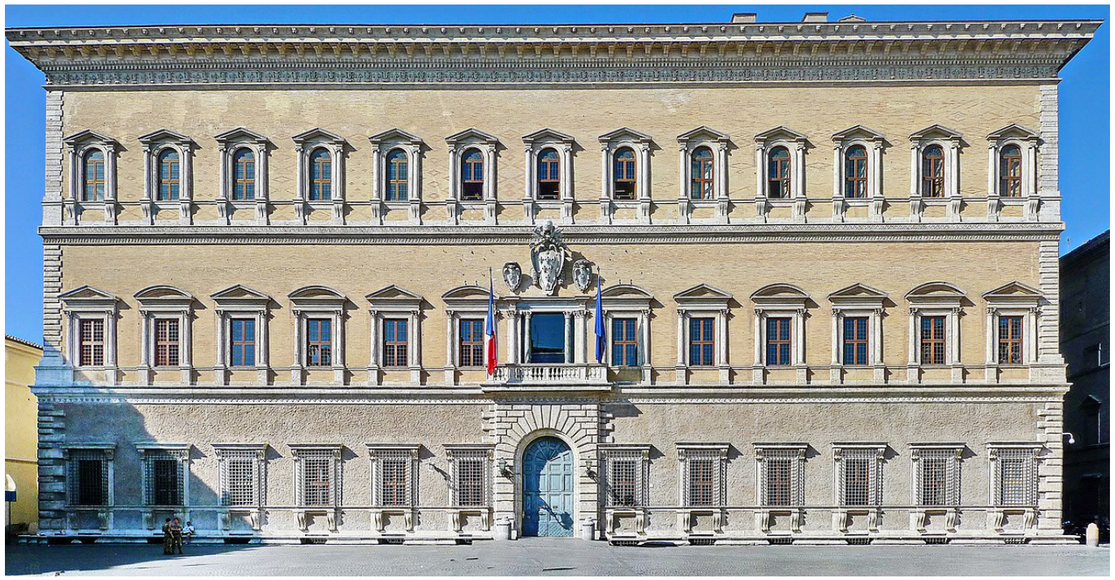
The façade organization is also a product of the internal program and functions; the heights of levels, rooms that need windows, load bearing structures, the shape of the building volume etc. All these factors are parts of the organization of the façade. But most of these features are not represented in the façade of modern logistics buildings. How can one arrange the rhythm and the expression of a simple box that has no determining features?

I decided to conduct an investigation to test out different facade composition principles. I studied numerous facades of long stretched volumes and found 20 of the most relevant façade compositions that has been applied. The inspiration is gathered from different type of buildings like simple warehouses to museums and renaissance palaces. Please see the attached PDF of some of my references.

I would like to point out that many of the most famous renaissance palaces in Italy is basically decorated sheds. The buildings are merely simple box volumes, but they are pleasing to the eye due to the rhythm of widows and organization of decorative elements.

Test questions:

- Does the composition make the box appear smaller or larger than the default test?
- Does it appear longer, thinner, aggressive, inviting etc.
- Does it appear more grounded, or more detached from the ground.
- Is it inviting to humans?
- Does the composition compliment the shape of the building?



Palazzo Farnese, Rome

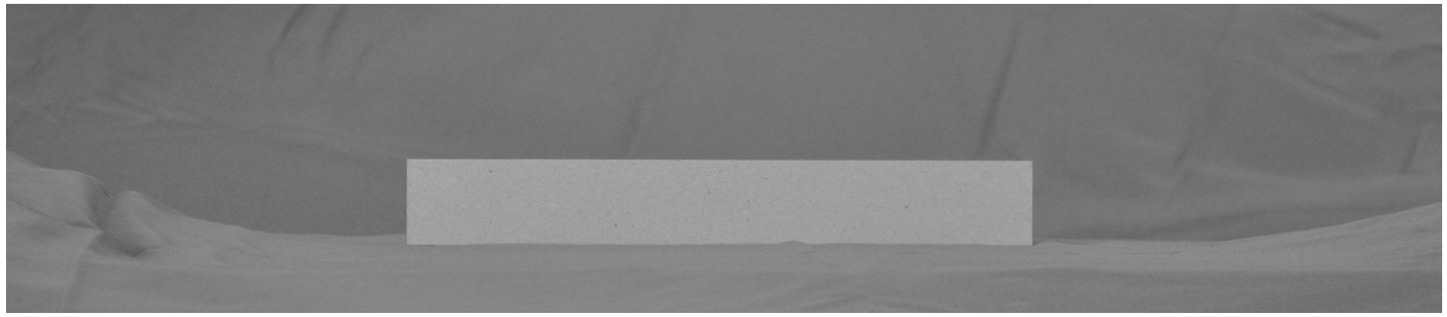
Palazzo Medici-Riccardi, Florence

Principles of façade composition

Principles of façade composition

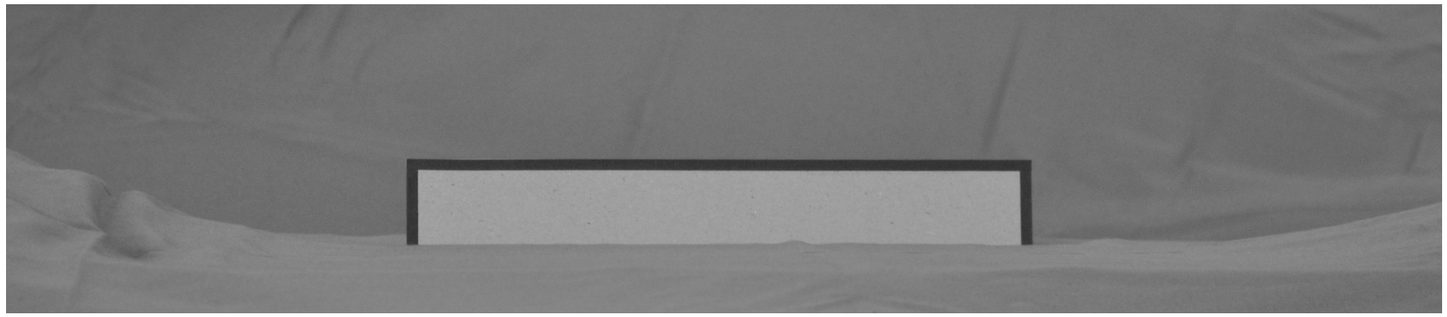
Test 0

This is the default facade when you don’t add anything to it – it is just a rectangular box. This is a quite defined volume but it is to some degree scaleless because it featureless. A clean façade makes a big statement. But the building is already a big statement because of its size. One can not overlook it or avoid being affected by it. Because of the big size it is inhuman, both for the people observing it up close and from a distance. In order for such a building to better meet the surroundings, it needs to be better grounded. This is extra important for large buildings that occupy a big part of the area in view – it becomes territorial.



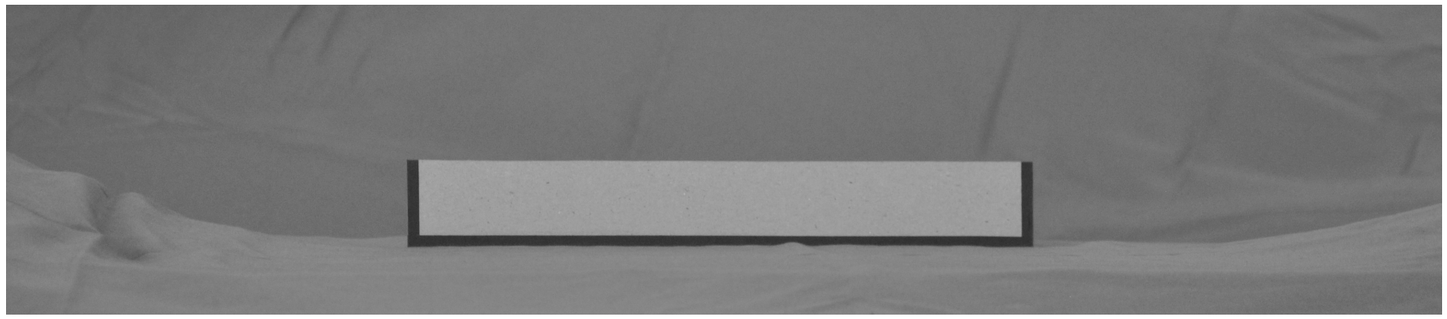
Test 1A

The framing defines the rectangular box even more and separate it from its surroundings. This makes the building appeared bigger because it so defined. But the dividing of the façade pulls in the other direction and makes it appear lower. It feels more strict and present. The framing makes it more grounded, but not more inviting to humans. The frame enhances the box shape.



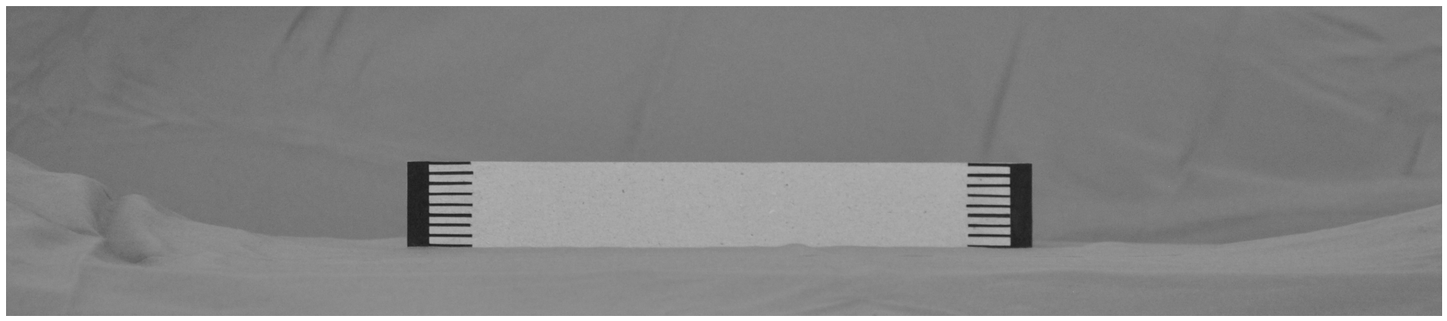
Test 1B

This test appears more grounded. This building seem bigger than the default test because it is a more defined shape. But it looks bigger than test 1A . Test 1B is more unpredictable, yet perhaps more pleasing to the eye than test 1A . I believe this is because it appears more open towards the sky and is pointing upwards rather than being pressed down.



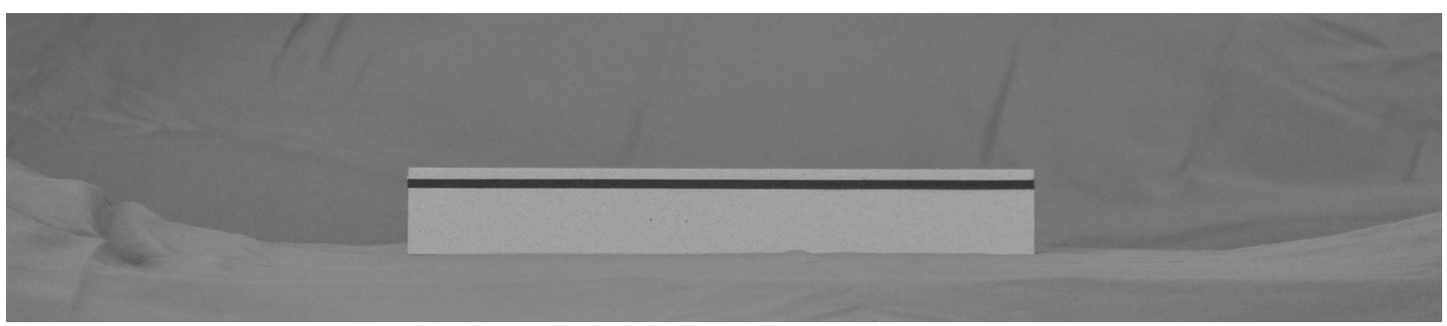
Test 2

The framing makes the building appear smaller because it is squished together from both sides. It is like an artificial shadow effect on the building . The framing makes the building look more brutal and more harsh than the default building. It does not look more grounded. The defined sides make the large blank volume curve a little, like it is bloating. This actually distorts the box shape. This building is not more inviting to humans, and it breaks with the landscape.



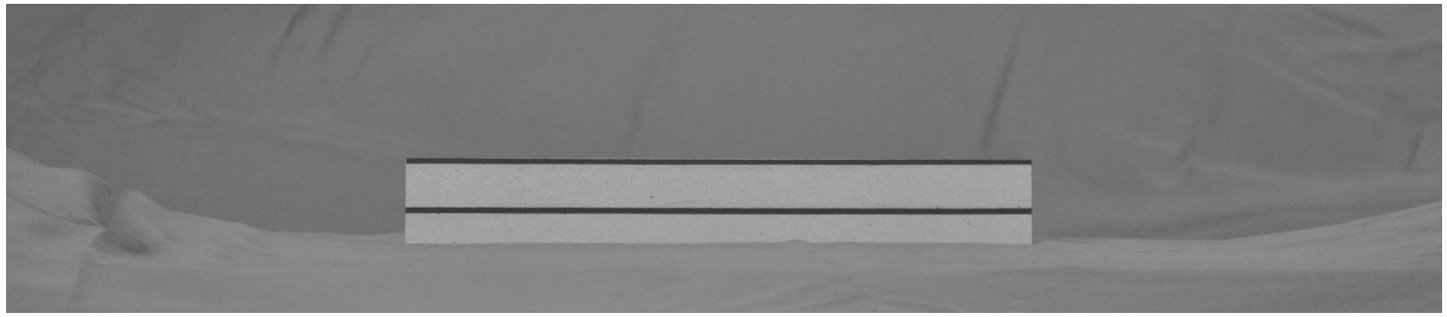
Test 3

Even though I’m quite annoyed by this sort of decoration on a building I must say it creates a more open and friendly impression then the default state. The horizontal line resembles the horizon as seen when looking out over a flat landscape or the ocean. Perhaps this resemblance makes associations with something that we know is beautiful and pleasant. It makes the building look longer and lower than the default test. But in total it makes the volume bigger. Not more or less grounded. If placed in a very horizontal landscape, this line would be a natural continuation of the place. The line catches the eye and makes the box a bit more interesting.



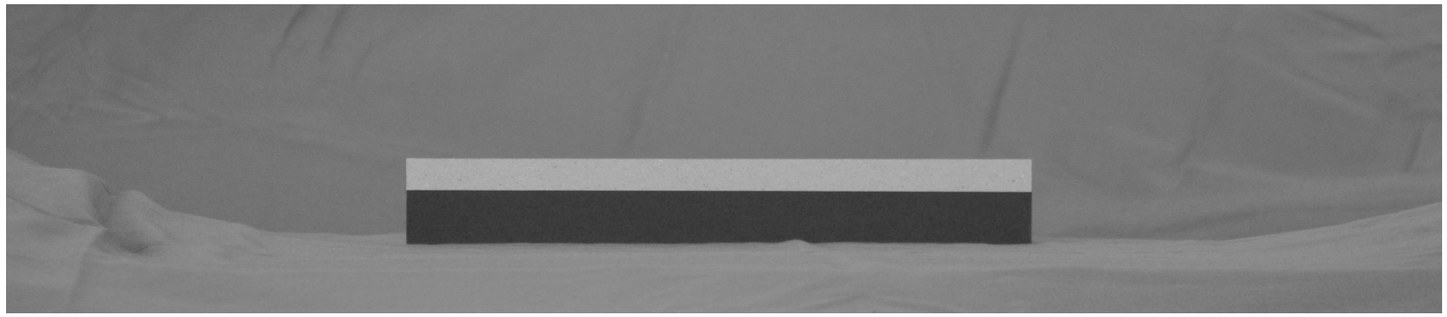
Test 4

The two horizontal lines reflect to some degree what is going on inside the building. The black lines indicate where the roof and deck should be. The two black lines makes the building sit heavier in the terrain. I realize that having something to focus on, even just two simple black lines, gives the eye something to hold onto. If feels good to focus on something familiar in contrast to the default facade where the box shape and the idea of the building is much more abstract – almost something intangible. Since the building does not have a clearly defined ending on the sides it blends better in with the terrain. If the colors are similar with the background it can appear as a continuation of its surroundings. The building becomes larger choosing a composition like this, but more inviting to humans because the façade is more relatable.



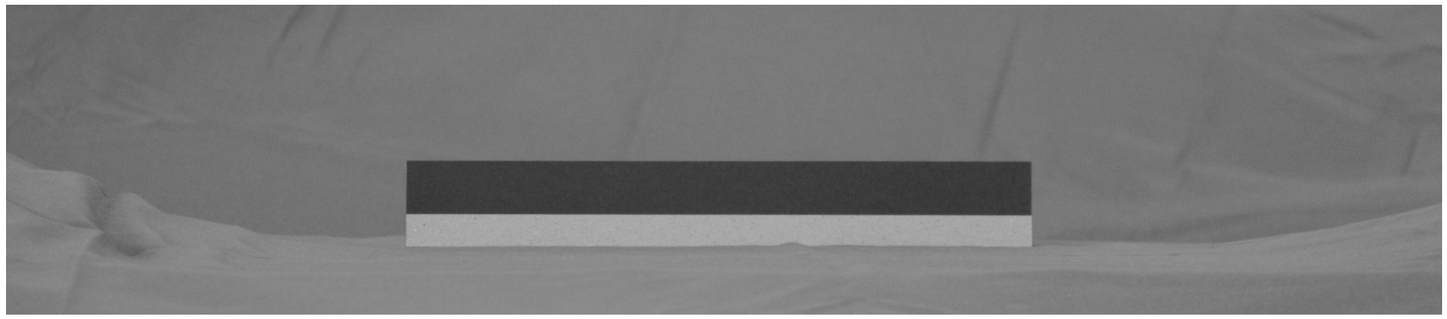
Test 5A

Having a large dark square field at the bottom, the building sit better in the terrain giving it a heavier foundation, center of gravity. The building looks smaller than the default state because the larger area at the bottom suggest that it is the first floor. Intuitively one assumes that this is of a standard floor height and deduce that the building is not as big as it really is. But the darker area also makes the building less inviting to humans because it resembles an impenetrable castle wall. The building appears longer because of the horizontal composition.



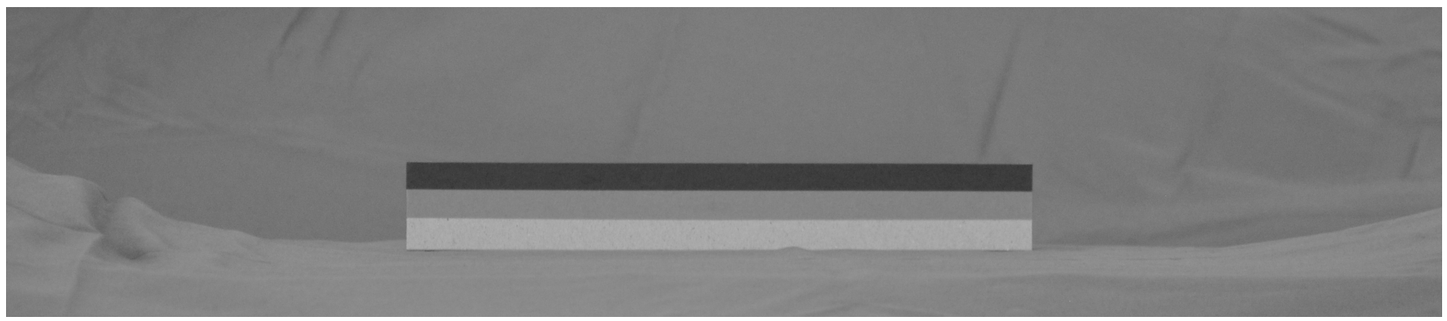
Test 5B

Having the big dark field on the top makes the building look like it is being pressed down appears more hidden. The dark field can also give associations to a gabled seen from the side. Both in test 5A and 5B one reads that the place for humans is assigned to the lighter areas. In test 5A you are lifted up, an in test 5B you are pressed down. Test 5B has the light area, the place for humans, on the ground, and is therefore more inviting.



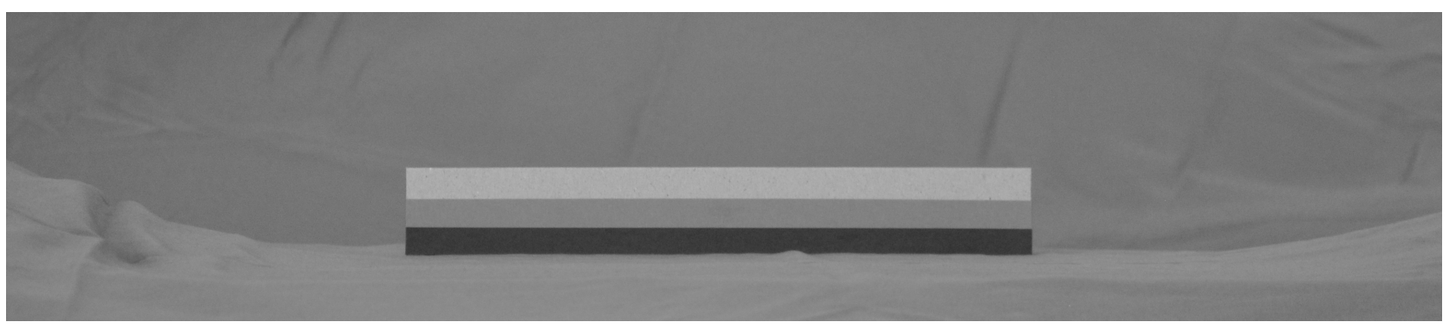
Test 6A

I would argue that this test makes the building appear larger than the default state. The building seems heavier than the default state, but perhaps more unbalanced. Because the center of gravity, or the heavier part, is at the top, it gives more dramatic expression. I wonder if the three layers make also the building appear taller because it gives the building a scale. Having just one box one can assume that the building only has one floor. But now there in this test the building has clearly three floors. This building is not very grounded. It is not a continuation of the landscape because it works as if the landscape has been turned upside down. Because of the scale and the layers, it is more inviting to humans. In itself this configuration of the façade is complimenting to the shape and makes it more interesting and pleasing to the eye.



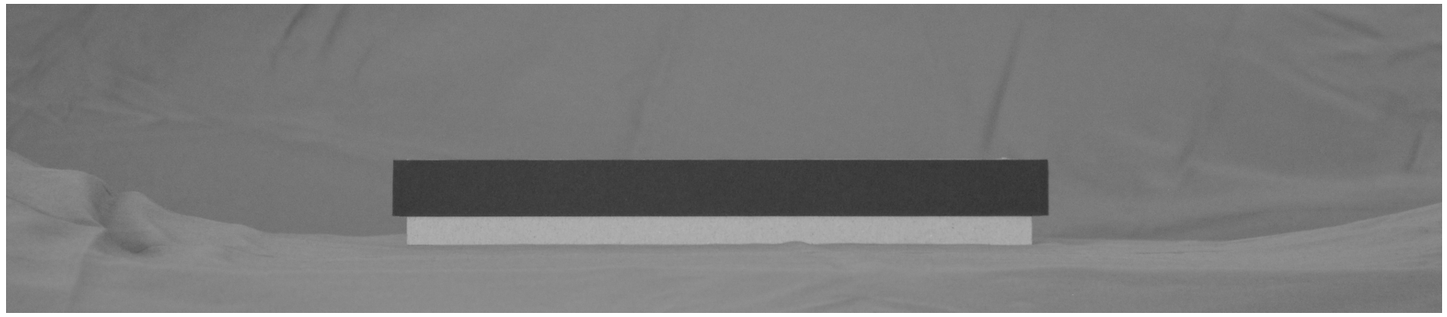
Test 6B

Test 6B reminds the eye of a situation found in the natural state where one sees different horizon lines. It is like when you’re looking out on the ocean and you see where the terrain stops and where the ocean stops and where the sky begins. So, there are many situations outside in nature where you have these three layers. Colors are more intense when they are closer and thus it makes more sense to have the darker colors at the bottom in contrast to test 6A where this concept is turned upside down. Therefore test 6B appears more grounded. Test 6B seems bigger than the default test- it feels longer. The principle with layers resemble stories/levels that makes the building more relatable to humans.



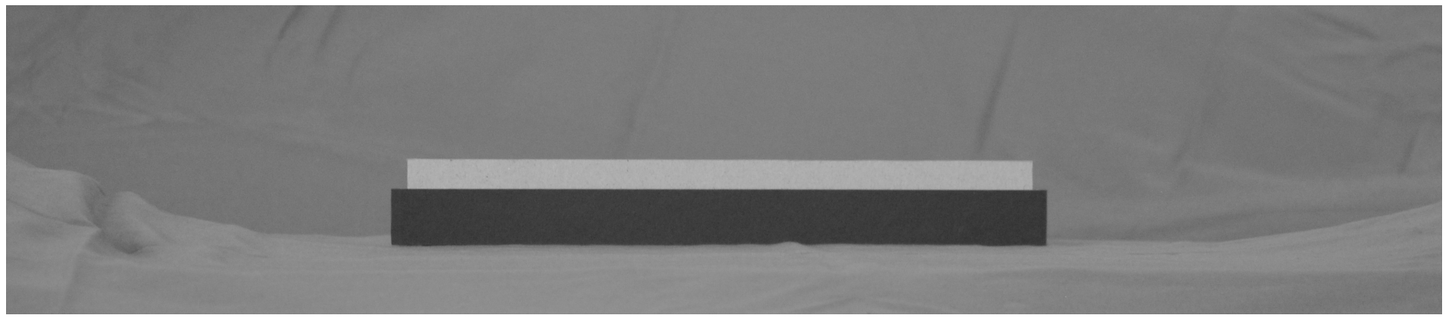
Test 7A

This test is of course closely related to test 5A and 5B, but here the large dark field is actually larger than the light one. Having the larger box on top makes an illusion of a floating box emphasizing the box's shape in the terrain, almost like lifting it up on a pedestal. I think an unstable building is not as pleasing to the eye than a building that rests firmly on the ground. The larger box clearly differs from the first level, and thus adding a human scale to the building. I think this would be a good quality when being closer to the building. But also one could argue that the larger unstable volume on top creates a unsettled atmosphere. This test underlines the horizontal form, and makes it appear longer. Test 7A is more inviting to humans because it has a ground floor reserved for humans. This test makes the box shape more stronger and alienates it from the surroundings.



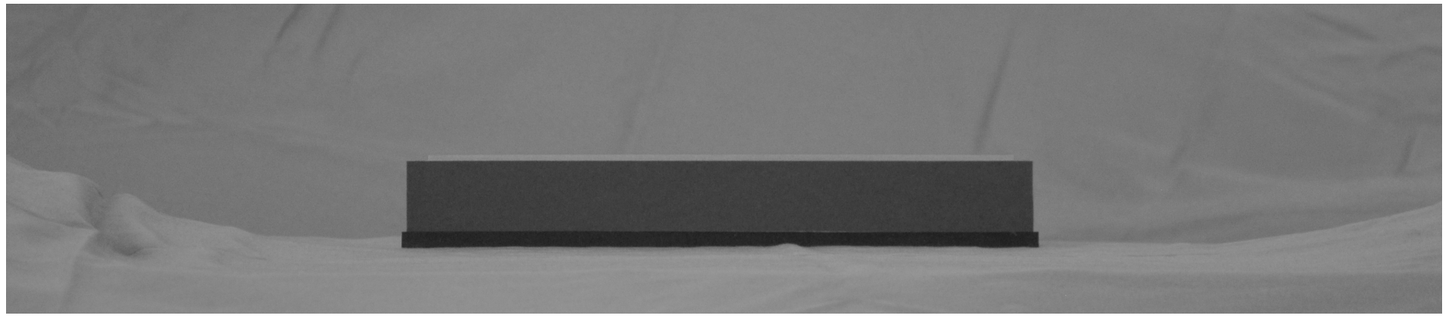
Test 7B

This configuration makes the building sit heavier on the terrain. It gives a more stable and fixed appearance, in contrast to the previous test where there is a floating box that could be more easily moved. Compared to the default state this configuration also makes the building appear smaller. The building is more anchored in the situation being a part of the terrain. It is not an abstract shape- a foreign object, but it appears to be more effectively communicating and interacting with the ground. But the tall first floor is appears more like a closed wall than an inviting façade.



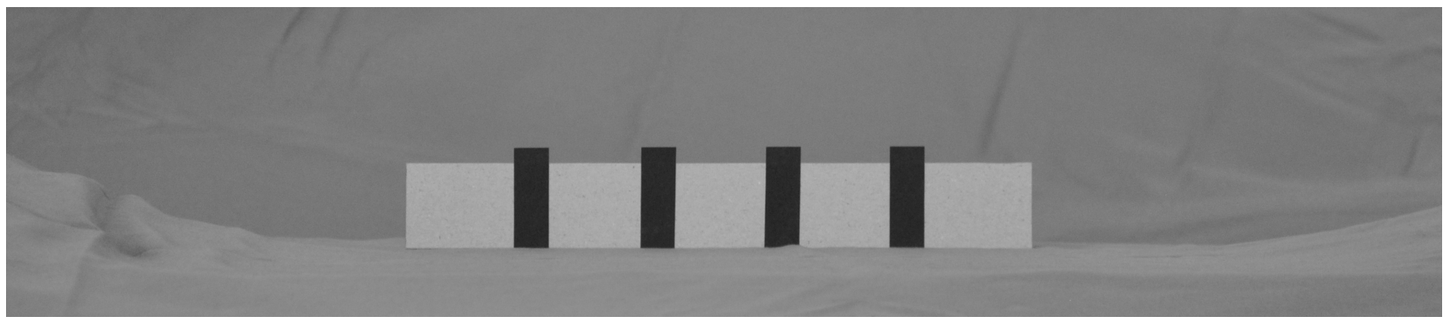
Test 8

This test is inspired by typical urban facades with a heavy first floor, a larger middle section and a very light top. By comparing it with the default state, one immediately sees that this building appears more friendly and more inviting to humans. The bottom strip, or foundation, gives a steppingstone or a threshold to the building. It is no longer an alien spaceship which landed there, but it is a building that one can interact with. Thanks to the ground foundation, makes the building sits better on the ground. This test is actually taller than the default tests because of the added field on the top . But still it does not appear taller than the default state. By using darker colors the building appears smaller in one way, in another way the building appears bigger because it has more floors and the eye can be tricked in believing that the first ribbon is an entire floor in itself, which it is not .



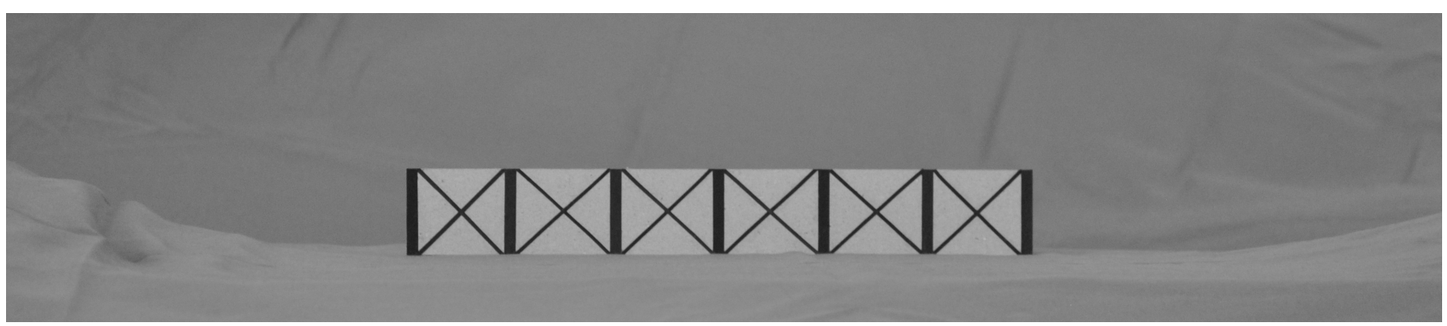
Test 9

Even though the black stripes add to the total surface area of the façade, dividing it up in smaller sections brakes up the impression of the larger volume and makes the building appear smaller. The black vertical lines are the feature that catches the eyes, and not necessarily the entire box itself. The observer is tricked to focus on the four stripes instead of the big box. This test also resembles something that is built, something that stands on the ground rather than a box that can be picked up and moved to a new location or place on its head or its sides without collapsing. This composition makes the building more beautiful, it is an interesting façade that makes you curious to what is going on inside. This composition is more inviting to humans because the vertical lines are perhaps resembling something familiar like traditional columns.



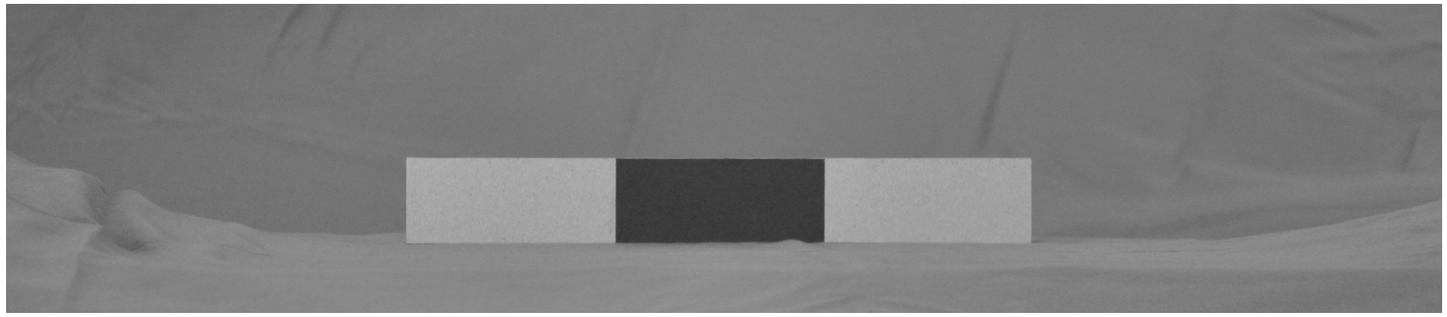
Test 10

This configuration actually makes the building appear larger. The framed squares with the crosses emphasizes the presence of the facade, highlighting the shape and width of the façade's surface. But on the other hand, it gives the eye more pleasure to look at. It is a pattern for the eye to recognize and features for the eye to focus on. The cross sections also creates a more depth in the façade because it has three layers: the columns, the crosses and the background. This does not make the building appear more grounded. I think the façade is a bit intimidating and not inviting to humans. This composition makes the building look very sturdy.



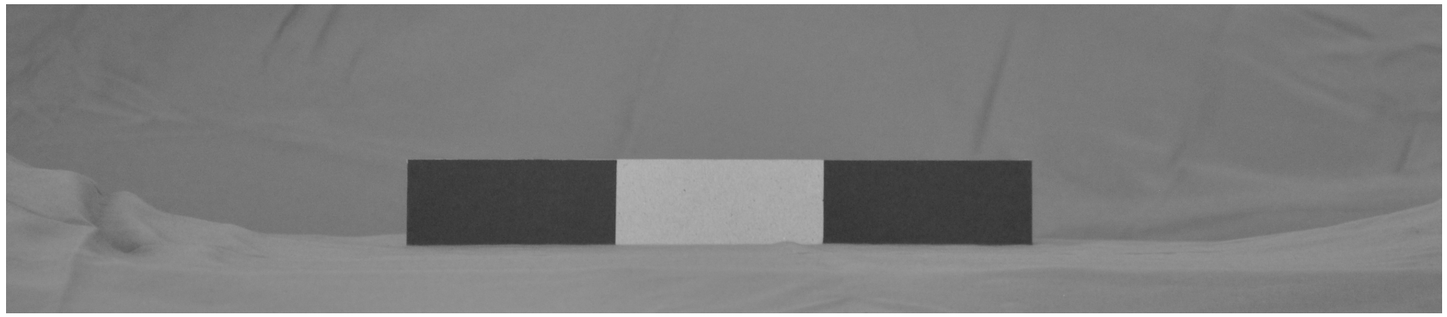
Test 11 A

When comparing test 11A and 11B, test A appears to be relating better to the ground than test B. This I believe is because the lighter areas are open towards the outside. When comparing test 11A and 11B, 11A appears smaller than 11B and it is more inviting to humans. The lighter areas appear to be closer to the observer and thus the black area is a nook that one can enter.



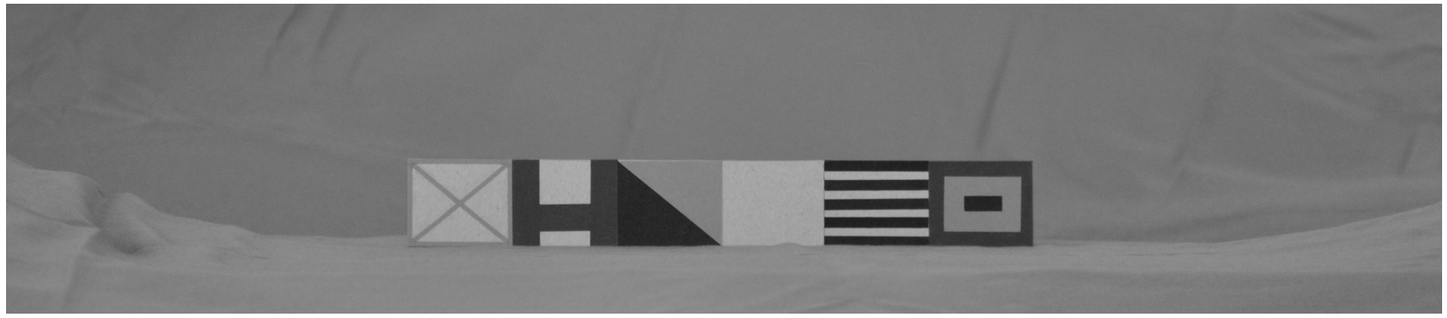
Test 11 B

Test 11B appears longer than test 11A, but both tests appear shorter and smaller than the default test. Both these two configurations help the box shape and makes it more beautiful. Test 11B has two big black walls protecting it from the sides and thus being more hostile to the environment.



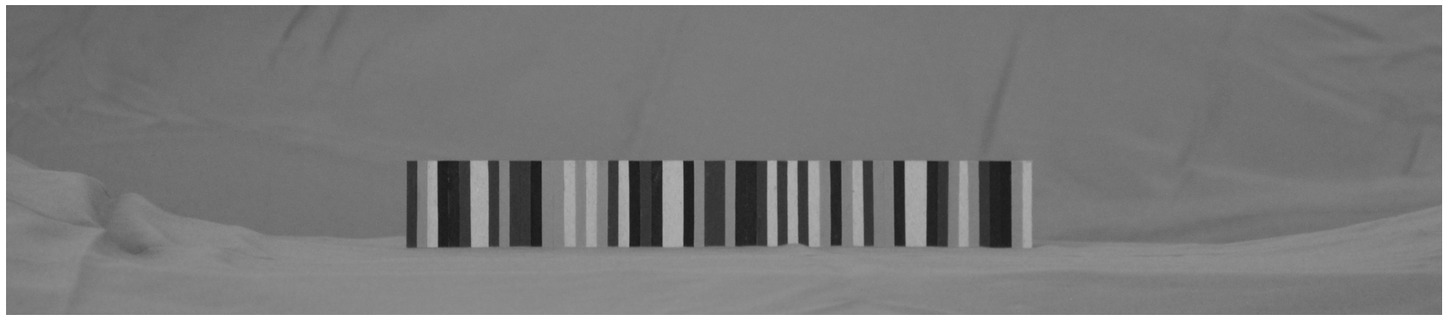
Test 12

When comparing with the default test, test 12 appears to be larger. It is taking up more visual space or at least being much more noticeable than the default test. But it is a quite fun house to look at since there is so much going on. One is tempted to try to find some connections or rhythm in the abstract shapes. This composition makes the building more visually intrusive than the default test, but the facade tales a story- it has a face and an identity. A building with a strong identity can contribute positively to its surroundings by creating a sense of place. It makes the place more unique. This is something considered of high value from the road authorities in Norway when they are judging public art projects alongside the road. The abstract patterns distort the understanding of the box shape, making it harder to recognize it as one volume. The unfamiliar façade is maybe less inviting to humans since one is not sure what this is.



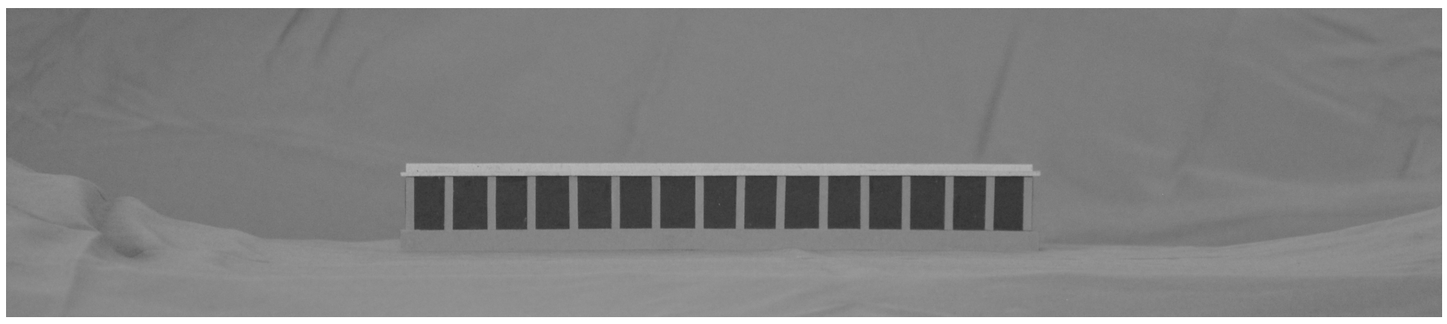
Test 13

The stripes distort the impression of the box and makes it harder to read as a shape. It resembles the ship camouflages from World War I when they painted geometrical figures on the boats to confuse submarines from reading the shape and the direction of movement. The vertical lines emphasize the height of the building and makes it taller as it is stretching up towards the sky. The stripe give the facade more depth to it, and it can resemble a forest. This makes the building appear shorter than the default shape. It is a more beautiful façade than the default one, and it makes a boring box more interesting. Test 13 has a more human scale because of the smaller dimensions and thus more inviting to humans.



Test 14

This facade is directly inspired by Palazzo Senatorio on the capitol hill in Rome. It follows the timeless principles we find in classical architecture. The test 14 configuration appears considerably smaller than the default box. The black areas behind the lighter ribbons creates a depth to the façade. I think this is because we recognize it as a colonnade with a more shadowy area behind. It is of course hard to judge this facade in comparison with the other tests because it gives so many associations with other buildings that we have seen. I wonder if it is unfortunate to associate a logistics building with a bank or roman temple. The heavy base gives it a balanced position and a low center of gravity. The base also gives a human scale and a steppingstone for humans. The lower part also makes it more grounded. It is a more beautiful version of a box than the default state.



CONCLUSION

Through this investigation I have learned that the composition of the façade has a strong impact on how a building is perceived. By arranging areas of a different character one can alter the appearance of a volume and give it a specific quality. In the black and white photographs of the tests, the different areas of the facades can represent either colors, materials, or surface texture. The darker areas represent something of a heavier character or more visually dominating than the lighter areas. It is not necessarily vital what the areas represents, but how they relate to each other.

Many of the tests complimented the rectangular shape and made it more pleasing to the eye. It is an effective way of improving a façade and can be achieved with relatively simple measures.

I would like to highlight test 8 as a good example of a composition that relates to the human scale and makes it more inviting. By giving the observer a relatable scale, the size of the volume can be better comprehended. I think this is particularly important for large buildings in order to prevent them from appearing as alienated objects in a landscape. Vertical lines, as found in test 9 and 11, reduces the impact of the long stretched rectangular shape. These types of compositions give a more balanced overall impression and is more pleasing to the eye.

I do acknowledge that the success of a façade is also highly dependent on the terrain and situation, and therefore not all principles shown here will be the right choice in every situation. But through this investigation I have learned what effect these principles have on a long rectangular shape and that the composition can be a strong contributing factor in making an ugly façade more beautiful.

Investigation 4: ADDITION

EPHEMERAL ARCHITECTURE

In my explorations of the typology of logistics buildings and how they are perceived, I have grown to be quite fascinated by the situation when one observes an object in motion. How is a building perceived when one is passing by in high speed? Thinking about relevant references, I started looking into art projects initiated by the Norwegian Road Authorities to be displayed by public roads in Norway. Besides improving the aesthetic qualities of a driver's surroundings, "road art" can contribute to avoid accidents and increase the traffic flow[1]. An important aspect to consider when working with art placed in relations to busy roads, is the fact that roads is a very public environment. In contrast to art displayed at museums and galleries, the audience driving on the roads is not necessarily choosing to experience the art piece by actively searching it out. The art is presented to them, almost enforced on them, as they are engaged in the act of traveling.

This concept is not something foreign or new in the world of architecture. Most humans are exposed to and affected by some kind of public architecture in their everyday activities without them actively choosing it. But an interesting common theme between "road art" and "road architecture" is the phenomenon of passing by. It is something we experience while being on a journey from one place to another. The travelers normally don't stop to take a closer look and thus choosing the terms on how to experience the art piece. The art experience becomes integrated in to the journey itself. Time and speed become important determining factors on how we perceive the object. Time and speed in its turn generates an new type of ephemeral architecture. Not in the traditional sense where a building only exists for a short amount of time due to the choice of materials or the nature of its use. This architecture is ephemeral in its experience, where the observer can only view the building for a couple of seconds.

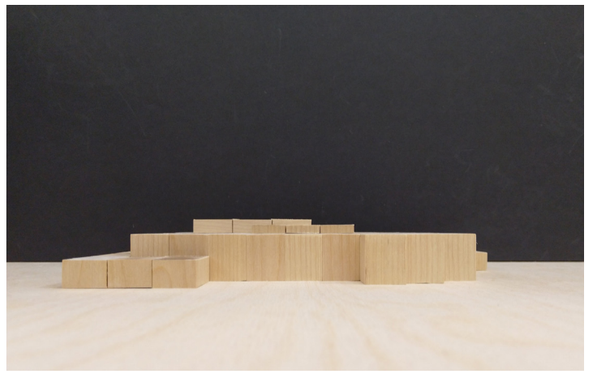
THE INVESTIGATION

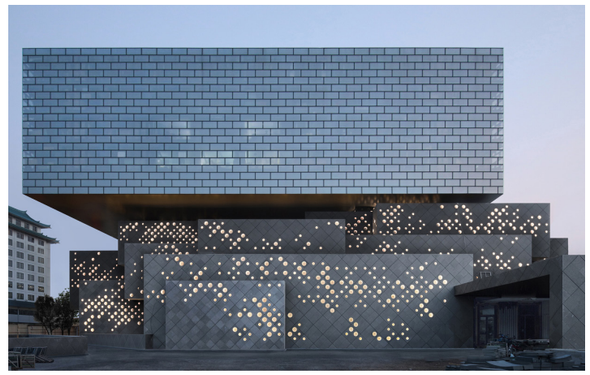
In this investigation I am further exploring ephemeral architecture caused by the movement of the observer. If one can not change the volume of the boxed shape logistics building, what can be done to improve the visual impact? I am looking at different solutions to add mass or features to the standard box shape to break up or alter the character of the volume. Can one redirect the observers focus onto something else? The tests are using the same technique as the first investigation dealing with building volume. Please see the attached video called "4. Addition.mp4".

1 Flatby, B.Å., (2009)

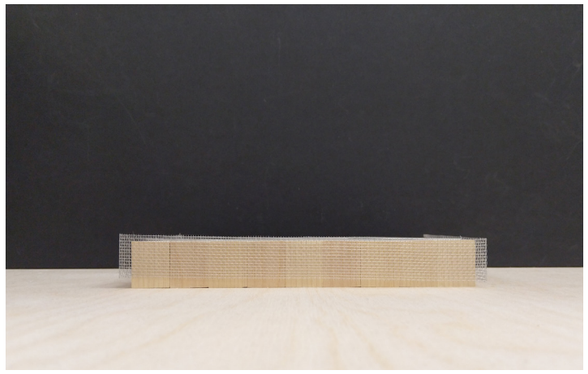
Test 0: RECTANGLE
This is the default state and the starting point for this investigation. This is the “ugly box” I am trying to make more appealing and interesting. The prerequisites for this test are same as for the previous investigations. I am using the Hydroscand volume with its 36 modules as a case study. All the following tests will have the same 36 modules. I am only adding matter to the default rectangle.

Test 1: VOLUMES
In this first test I have added smaller volumes to the big box. The volumes are based on the “Bulk Module”, but have either become lower or cut in half. Since I am using the same rectangle in all the tests, this addition would of course in reality ad a lot of extra space. The additional volumes effectively makes the original box “disappear”. It appears to be several slabs melted together. The viewer’s attention is focused on the horizontal lines and the spaces created between the volumes. The building resembles an abstract mountain or classical temple stereobate. This may feel more inviting to a human. The additions help the rectangular volume blend better in with the surrounding

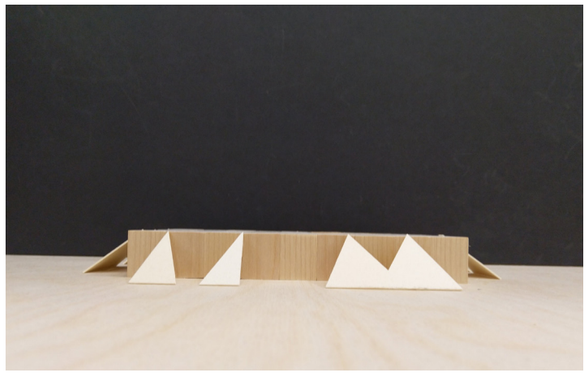




Test 5: MESH
Mesh is often used by architects for its visual and functional properties. It is a second layer - a semi-transparent outer skin often used for sun protection. It provides an alternative to traditional window shadings to filter the sunlight and reduce heat. Draping the façade in a mesh gives a more unified and cleaner façade. This could be beneficial when interior functions generate messy window layouts or boxes and pipes on the outside. It also creates an interesting depth and light quality to the façade. Using mesh on the whole façade would enhance the box shape, which may not always be beneficial. This strategy does not do anything particular for the box shape when seen in motion. The mesh only ads a second layer the to existing shape.

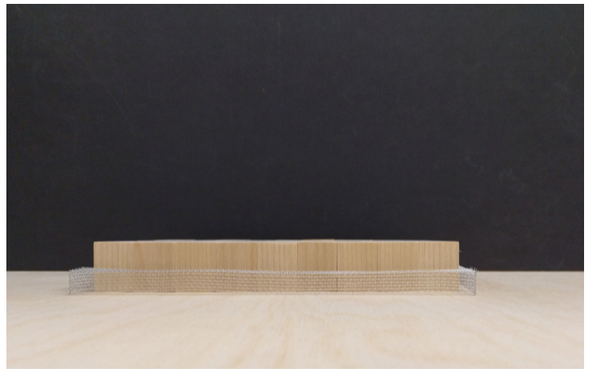


Test 8: TRIANGLES
This strategy is about adding panels that would alter the contour of the box shape. The triangular additions could be inclined roof surfaces that create sheltered outdoor areas. They resemble guylines or canvas that stiffens the structure horizontally. To some degree, this addition takes the focus away from the box, yet the rectangular shape is still present in the experience of the building. In motion the triangles are hiding spaces that create a certain curiosity. They tone down the rigidity of the box and thus can help with feeling more integrated in a landscape.



Test 14: CANOPY

Adding a canopy to the structure will create sheltered outdoor areas that could give a human scale to an industrial environment. It makes the building look more approachable and “mild” in its expression. The canopy makes the structure feel more grounded and stable, but it also adds to the horizontality of the building. This strategy does not alter the experience of the building when seen in motion. But in general, adding a feature like this could create a more soft transition with the surroundings.

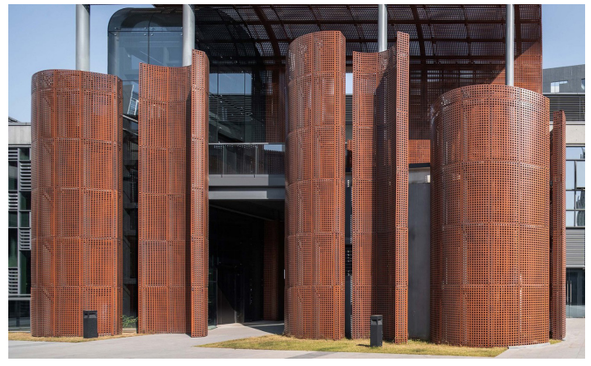


Test 15: FRAMES

This test makes the box more interesting as an object. The frames become the dominant feature and thus weakens the experience of the box. The frames appear as the load bearing structure and the box is given a more fragile character. The inside of the box is more present, even though one cannot see it, since the exposed structure is saying something about the quality of the interior space. A “clean” box does not say much about the interior, and anything could be happening on the inside. This strategy could be effective in taking the focus away from the box shape. Especially if one developed the trusses, it would make an interesting experience for the bypassers as the lines would interact and form changing patterns. In other words, there is potential for this to work good in motion.

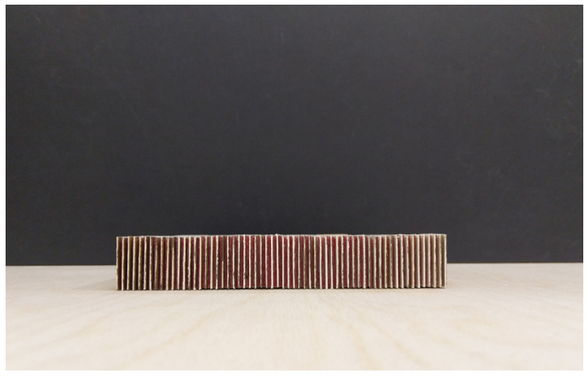
Test 18: PANLES

These added structures can help hide parking lots and messy outdoor areas filled with containers, machines and other things stored outside. Also, highways are usually incredibly noisy and these screens(panles) can potentially help with noise absorption so that the conditions for outside work is better. Observing these structures in movement enhances the spaces that is formed in between the panels and help the observer to discover and understand this complex spatial condition. It creates an interesting effect because of the variation of depth or distance between the panels. This strategy demands a lot of outdoor area which may not always be available in every project. But this test reduces the visual impact of the box and makes a smoother transition to the surrounding environment. The border between the inside of the box and the exterior is now more broken down, I think this would help in making the project appear more inviting to humans.



Test 19: FINS

In this test I have added a series of fins on the façade. This strategy can help directing the view of people inside and protecting internal workspaces of direct sunlight. The fins have a different color on each side and the gap between them is of a third color. This feature makes the building change color when driving past it. Approaching the building from the right side, it seems to be painted brown. When viewing the building perpendicular to its façade, a pink “wave” appears, and then the building’s color change again to white as one sees the facade from the left side. This could be beneficial when dealing with a situation where there are two very different conditions on each side, and the facade’s color scheme needs to correspond to both. The addition in itself does not necessarily alter the shape of the rectangular volume, but it does make the box more fun. It is a feature that is directly relating to moving observers. It makes the box an object of curiosity. For companies that would like to be noticed, and have a building that people really look at when passing by, this could be a rewarding strategy.



CONCLUSION

In this investigation I have explored how one can improve the experience of moving past a boring rectangular volume. I found that there were several strategies that seem to work well for a building observed in motion. If it is not possible to avoid box shaped buildings because of a specific program, there are still lots that can be done to make it more interesting and fun. This is also something to consider for logistics buildings already built, in order to improve the outward expression and help contribute to the surrounding situation. These added features can also give more value to the project like providing better outside spaces or improve climatic conditions inside. But many of these tests dramatically increases the buildings “footprint” and thus requires a lager property. Adding a lot of structure would of course increase the total cost of the project.

Finally, I want to highlight test no. 18, the panels, as one of the more successful strategies. Although very space demanding, the panels seem to give a lot of value to the project both functional and visually. The effect could be achieved with relatively simple structures and does not seem to be too unrealistic in terms of economy. If placed correctly, I do not think the panels would need to interfere with the outside circulation and other operations around the building. The way many companies use their outside areas as additional storage spaces creates an ugly and unorganized visual impact on their surroundings. The panel strategy could be used to avoid this problem and at the same time provide more comfortable spaces for the workers. I think this addition would make an ordinary boring logistics building alongside a highway, into an interesting and fun point of the journey.

Investigation 5: SURFACE

SANDWICH PANELS

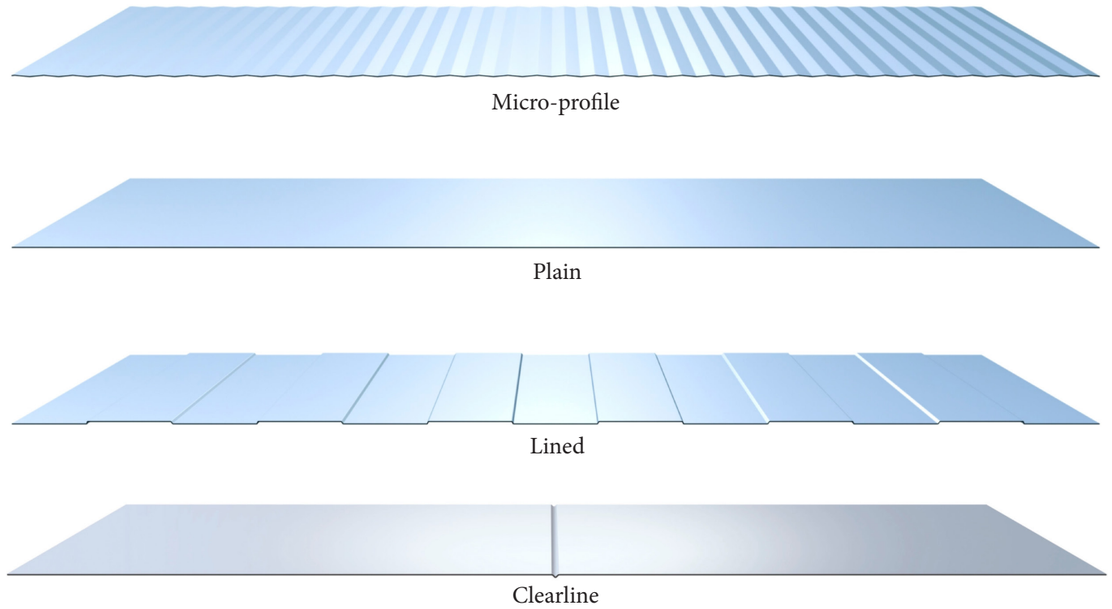
Most large scale logistics buildings use sandwich panels as external cladding. This composite material offers excellent thermal insulation while being fast and easy to assemble. It is a complete wall solution where outer cladding, insulation, vapor barrier and internal cladding are combined in one product. The panels used in the building industry are usually made of two galvanized steel sheets with a core of rigid polyurethane foam or mineral wool. The latter has the advantage of being non-combustible while the polyurethane foam provides better insulation and is usually cheaper[1].

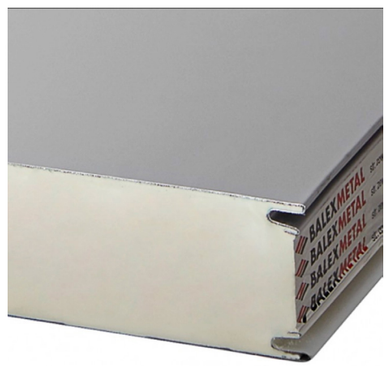
The steel sheets act together with insulating core as a composite that gives good structural strength compared to its low weight. The panels are self-supporting and resistant to weather and wind loads. Together with its technical properties this product often chosen for its low maintenance and lifetime cost. It is an off the shelf product of low cost that can be used in numerous applications like external and internal walls, roofs and ceilings[2]. Another important aspect of this material is the fact that it is easy and quick to assemble. The panels can be directly mounted on the load bearing structure using self drilling screws with a watertight gasket. In an interview I had with Borga, a Swedish steel building manufacturer, I learned that they normally estimate 30 min per panel in installation time. They reckoned that for a building similar in size to Hydroscand they would have completed all external walls in 4 days.

During my research on logistics buildings I have been in contact with “Balex Metal”, a polish manufacturer of sandwich panels. I have used their products and pricing information as a basis of comparison in my investigations. In my understanding Balex Metal is a “typical” manufacturer of sandwich panels and the performance and range of products seems to be representative for many other manufacturers.

“Balex Metal” delivers a wide range of sandwich panels with different texture, edge profile and color finishes. The surface of the panels can only have one color, but it is possible to have different colors on each side. One can choose from an assortment of standard colors or one can order custom colors, but this would require an additional cost. The cost of a panel equal to what is being used in Hydroscand, a 120mm polyurethane core with 0.19 W/m2 K insulating efficiency is 283,47 NOK per m2.

The sandwich panels can be mounted either vertical or horizontally. With the “Bulk Moduel” a vertical orientation of the panels would require additional support systems. Windows are installed after the panels are mounted by simply cutting a hole in the wall where the window should be. If the windows are not too heavy, there is no need for any one other structure due to the strength of the panels alone. This is one of the reasons why many logistics building only has a narrow strip of windows running across the façade. It is a result of the inherent possibilities and limitations of the sandwich panel wall. The sandwich panels are fabricated in external factories and transported to the construction site using trucks. They can be delivered as long as 18 meters and normally either 1000mm or 1100mm wide.





Detail of sandwich panels

1 Balex Metal 2020
2 Designing Buildings Wiki 2020

THE SURFACE OF LOGISTICS BUILDINGS

Even though the sandwich panels have outstanding technical qualities, the emotional result of a “sandwich” façade often ends up being poor. The endless repetition of steel panels creates a boring and lifeless sensation. Steel as a façade material is not the problem. Studied at close range the texture and surface quality of the panels gives a clean but sturdy impression that goes well with a building of an industrial nature. There are also many good examples out there of other building types where the use of steel façades creates excellent architecture.

Sandwich panels used in the context of a logistical building simply looks really cheap. It is perhaps too honest. Even thou a composite material, there is little “fake” about the sandwich panel façade. The “material” or more precise; product, observed from the outside is the same as what is on the inside. One can clearly see how everything is put together; one panel is stacked on top of the other. Because of the joints and visible bolts one can identify the supporting structure behind the facade carrying the loads down to the ground.

I believe another problem lies in the scale. Encountering an enormous logistics building at close range can be an intimidating experience. The endlessness of this very large surface makes one feel small and misplaced. The building becomes inhuman. I think what would help this negative effect is introducing something that would tell a story that this was built by humans. Either by choosing materials that can be handled of a person like bricks or wooden tiles, or traces on the surface of human activity like brush strokes or chisel marks.

One strategy to address this issue, is to add a secondary layer to the sandwich panels. This can be done with great result like in the Ricola Building in Laufen by Herzog & de Meuron. Other projects have added features like wooden fins or ceramic tiles to the sandwich facade to make it more interesting and relatable. Even thou some of these secondary layers can give added value in visual and perhaps also technical terms, this addition will make the project more expensive. The sandwich panels make a “complete wall” in itself and do not need anything “extra” to function properly.

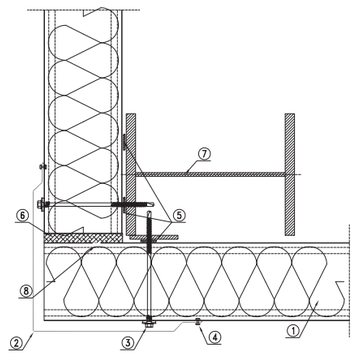
Jean Prouve experimented with sandwich panels in the Maison Tropicale in 1954

Ricola Building in Laufen by Herzog & de Meuron

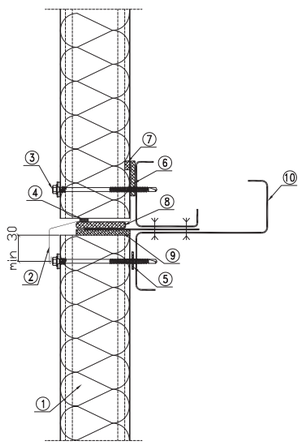
Carlsberg Innovation Centre by S&AA

THE INVESTIGATION

In this investigation I am looking at other alternatives to sandwich panels. Since these panels are a complete wall system, the other alternatives I am looking at needs to be that as well for us to compare prices. The cost of for example a brick wall must include the bricks, insulation, and inner cladding of some sort. In this price comparison all expenses are accounted for, like labor, assembly, material, etc. I will not be testing the success of the other materials, but simply showcase the alternatives to sandwich panels and to establish a catalog of materials for my further studies.



Joining panles in corners
(Courtesy of Balex Metal)



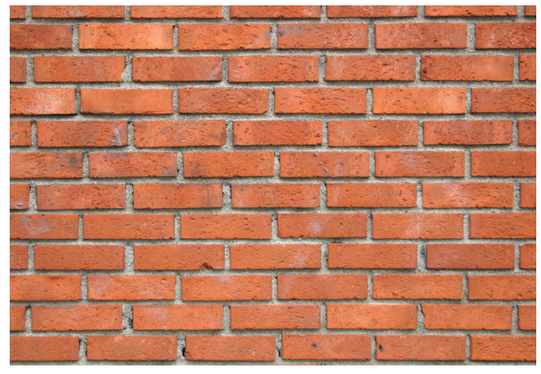
Joining panles lenghtwise
(Courtesy of Balex Metal)

SANDWICH ELEMENTS

240mm
Mineral wool core
Cost per m2: 1 730 NOK

BRICK WALL

150mm insulation
180mm interior loadbearing concrete wall
Cost per m2: 4845 NOK



EXPANDED CLAY BRICKS

300mm isoblock
With render
Cost per m2: 2 203 NOK

SLATE WALL

150mm insulation
180mm interior loadbearing concrete wall
Cost per m2: 6773 NOK

TIMBER FRAME SYSTEM

250mm
Vertical timber external cladding
Cost per m2 : 1 353 NOK
(Additional supporting structure is not include)

CLT ELEMENTS

With 200mm insulation
Cost per m2: 4 603 NOK

PRE-FABRICATED CONCRETE SANDWICH ELEMENTS

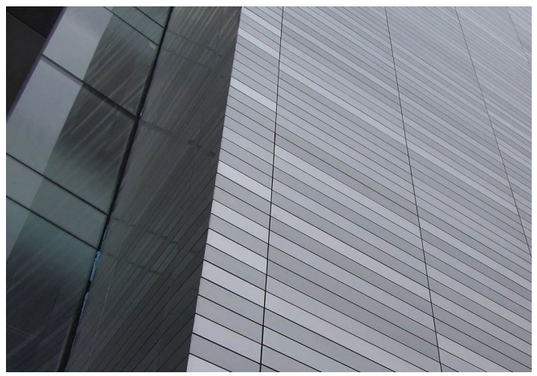
400mm
Not load bearing
Cost per m2: 3 130 NOK

CORTEN STEEL PLATES CLADDING

250 mm steel frame wall with insulation
Load bearing structure not included.
Cost per m2: 2556 NOK

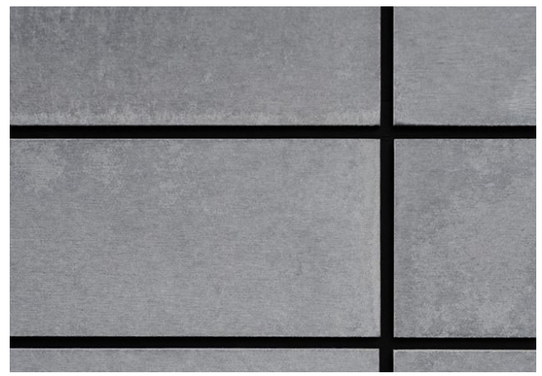
STEEL CASSETTE CLADDING

250 mm steel frame wall with insulation
Load bearing structure not included.
Cost per m2: 2717 NOK



FEIBER CEMENT CLADDING

250 mm steel frame wall with insulation
Load bearing structure not included.
Cost per m2: 1974 NOK



CONCLUSION

I was surprised to see that there where many other reasonable wall alternatives to sandwich panels when only looking at the building cost according to “Norsk Prisbok”. It must be said that the price estimate for sandwich panels is based on an average of different thicknesses available, so choosing a very thin panel type would potentially be the cheapest alternative in this test.

What this investigation does not take into consideration, is the increase of construction time. That means that a business will have to wait longer until they get a return on their investment, and the financial costs will be higher the longer it takes to complete the building project. Sandwich panels are a very lightweight material in relation to its thermal and physical properties. Using other, heavier materials or wall systems may result in an increased need of load bearing structure, which in return will increase the cost. In addition, the maintenance cost for wood facades and other materials will be significantly higher compared to that of the sandwich panels.

Investigation 6: LIGHT OPENINGS

Logistics buildings too often lack a face. Their façades are normally without any features that makes them relatable in an emotional way. Thy do not crate a dialog with the observer where one can start to understand what this building is for and how it is to be inside. There is just an “empty” wall. It is like talking to a person without a face or that has turned his back to you. As humans we strongly relate to the eyes of the person we are talking to. I think the same applies for buildings, we are searching for eyes to better understand the large object we have in front of us.

Windows are the eyes of a building. They tell a story of how the internal spaces are organized, what people are doing inside these spaces and potentially shows what this building is made for. At night, lit windows gives a clue that someone is inside, working late, making food or just dwelling in this house. Windows are an important link between the humans outside the building and the people inside. They give the building a “face”.

I believe giving a building a face can be achieved in several ways, it does not have to be the traditional windows. There are other materials and qualities that also gives a building something the observer can relate to.

So why are there normally so few light openings in logistics buildings? I have found that there are several answers to this question. For some companies it is unacceptable to have windows. This could be because they need to protect light sensitive goods and/or industrial processes. Large window areas could also contribute to an unstable indoor climate, which may not be positive for certain programs. Windows and glass facades are also quite expensive compared to just regular sandwich panels. Inserting a window requires extra time and labor. And if the windows are very large, one needs additional loadbearing structure as well.

Another reason for the lack of windows in logistics buildings is that building authorities often do not require a certain amount of daylight in these kind of spaces. In Norway the authorities require that the developer provides a sufficient amount of daylight for spaces intended for work and permanent stay. But an exception is made for especially large spaces like warehouses and industrial facilities. This exception applies also for the Hydrscand building where the required daylight factor is not met in the main storage.

Person without a face

Facade without a face

Earlier in this semester I visited the Hydroscand building and talked with several of the employees. When I asked the person who had been in charge of the planning of the building why there were so little windows he answered that they simply did not need them. Their windows are mainly placed at stationary work areas, like the offices in the mezzanine floor. In the large storage hall the pallet racks would “hide” the windows. Also direct sunlight could be disturbing for forklift drivers. So Hydroscand, as so many others, choose to light up their large hall with mainly electric lamps.

THE INVESTIGATION

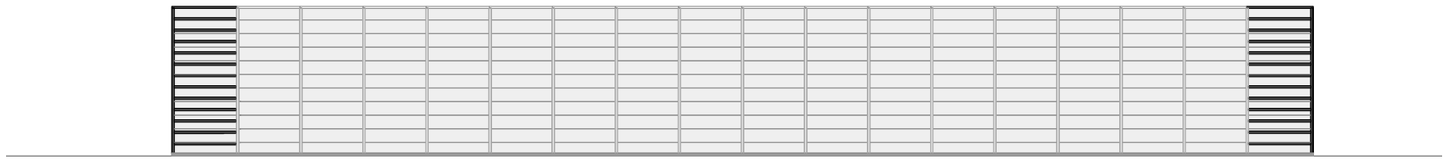
I am exploring different ways to provide daylight in the main storage hall of the Hydroscand building, and how cost efficient the different alternatives are in relationship to their light transmission qualities. The Norwegian Building Authorities (DIBK) requires that rooms intended for permanent stay, like offices, needs to fulfill a daylight factor at of minimum 2%. The daylight factor is of course quite complex to calculate if one needs to be very accurate. On DIBK’s website they provided a simple formula for smaller projects. I will use this simplified formula in this test since the goal is not to document that the requirements of the law is met, but to have a basis for comparison for the tests that is not totally unrealistic.

The formula is: $Ag \geq 0{,}07 \cdot ABRA / LT$
Ag – Window area
ABRA – Floor area
LT – Light transmission of material

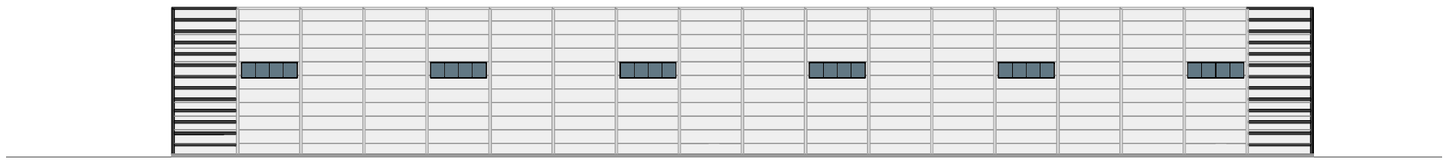
The storage hall of Hydroscand has a floor area of 6000m2. I am conducting the test on the south-west facing wall of the building, which has a surface area of 1360m2. This wall is the most eligible to have windows according to the program inside. The room also have three other walls where it would be natural to place windows. Therefore, in this test I will place 50% of the required windows on the test wall.

SANDWICH ELEMENTS ONLY
Total cost of façade: **2 352 174**

Cost per m^2: 1729,54
Core thickness: 120mm
Insulating efficiency: 0.18 W/m^2K

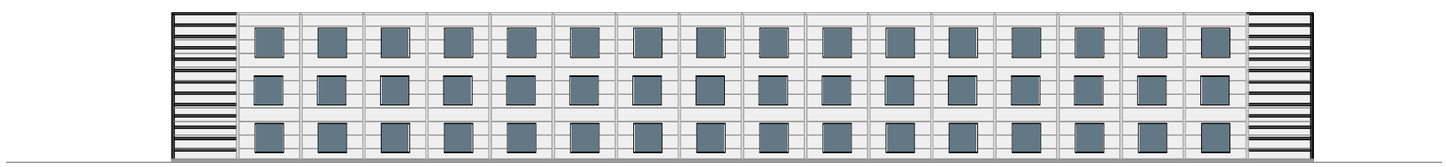


HYDROSCAND
Total window area: $34m^2$
Total cost of façade: **2 463 370**



TRIPLE PANE WINDOWS
Required surface area: 280 m^2
Total cost of façade: **3 269 348**

Cost per m^2: 5 005,16
Light transmission: 75%
Insulating efficiency of windows: <1,2 W/m^2K

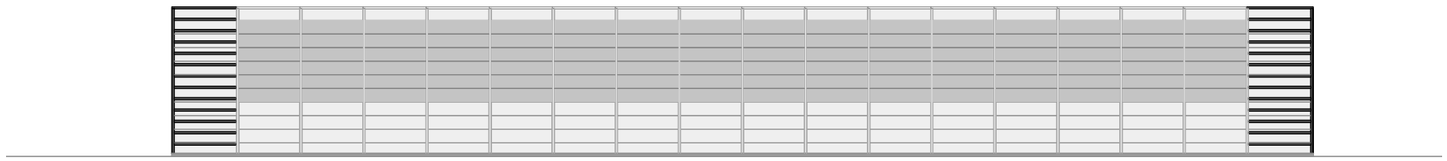


GLASS FACADE
Required surface area: 280 m^2
Total cost of façade: **3 269 348**

Cost per m^2: 4 223,97
Light transmission: 75%
Insulating efficiency of windows: <1,2 W/m^2K

POLYCARBONATE SHEETS
Required surface area: 626,25 m^2
Total cost of façade: **2 090 412**

Cost per m^2: 1 252,69
Light transmission: 32%
Insulating efficiency of windows: 0,8 W/m^2K
Material thickness: 55 mm



GLASS FACADE + WIRE MESH
Required surface area: 626,25 m^2
Total cost of façade: **7 073 897**

Cost per m^2: 1 759,98 (mesh)
Light transmission reduction: 70%
Material weight: 5,3 kg/m^2

CONCLUSION

In this investigation I have learned that fulfilling the 2% daylight factor for large interior spaces like the main storage in Hydroscand require much larger window surfaces than what we normally see in logistics buildings. Also seen from an economical perspective providing sufficient daylight in a warehouse is a big investment for something that is not technically necessary for the building to proper “function”. The polycarbonate sheets seem to be a promising strategy for providing daylight and giving the façade more distinctive features. The polycarbonate sheets used in this test does not have the same thermal properties as sandwich panels, so this will of course add to the total cost estimate.

APPLICATION

Through my investigations I have learned several principles and potential design strategies. Now I want to apply some of these findings in a single project, re-drawing the Hydroscand Building at the site in Lindeberg.

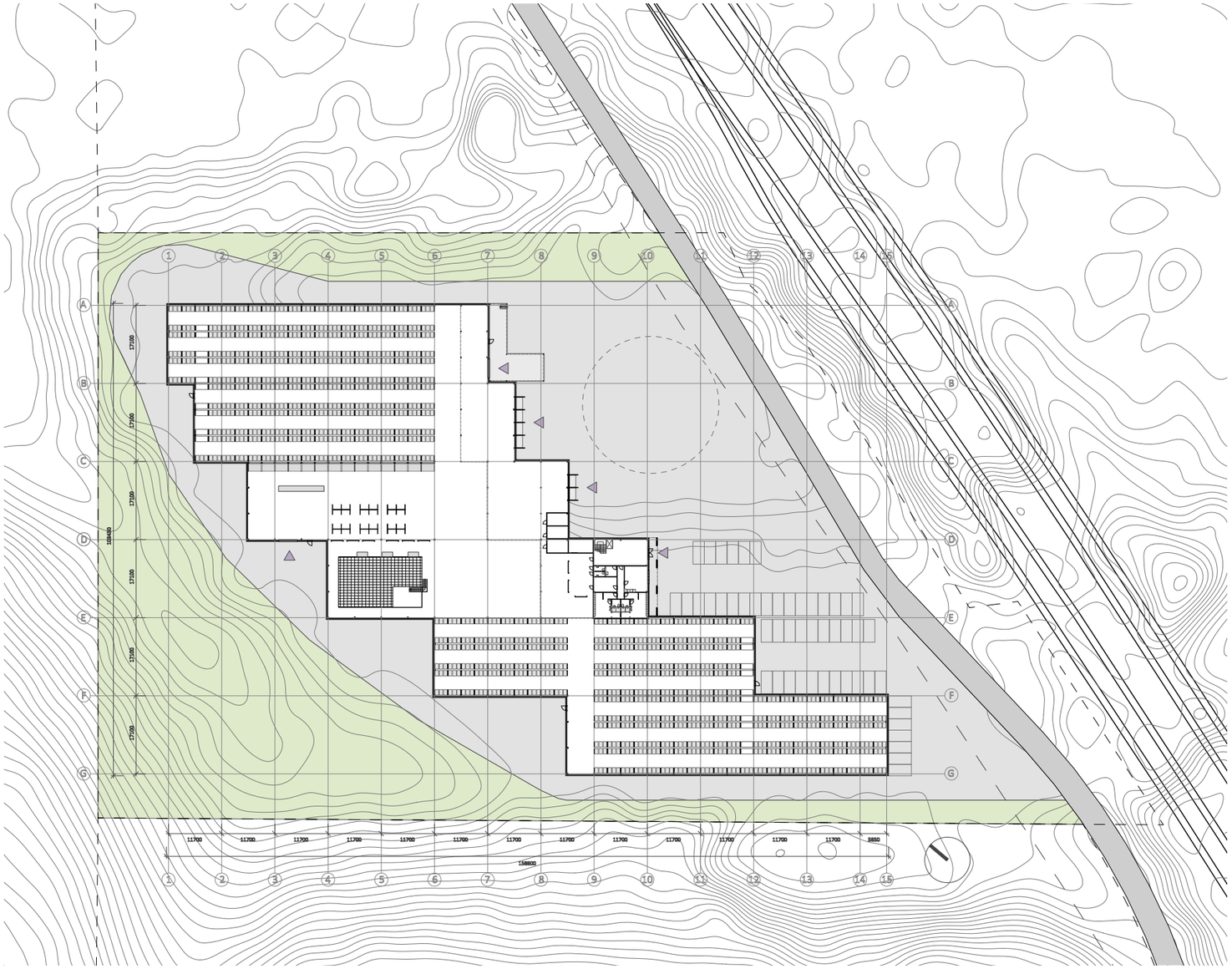
To begin this process, I revisited my original list of critical points to see how I, in the best way, could respond to them through the results of my investigations. I believe there are many of my results that could have been applied successfully to the Hydroscand project to improve the overall visual impression. While considering different strategies I realized that the “theme” of investigation no. 1, the Volume Study, is perhaps the most efficient and the most significant way to improve the appearance of an ordinary logistics building. Test no. 16, the curved configuration, addresses several of my critical points as well as being a very suitable building shape for inclined sites like the one at Lindeberg.

Using the curved volume strategy as a starting point I began to explore the site conditions and operational and the programmatic requirements for the Hydroscand project more in detail. Working simultaneously with the floorplan and the relations to the railroad, the highway, the topography, and the site lines, I began to establish a form and position that was more site specific. As my proposition developed, I realized that not all my investigation results would work well with a shape like this.

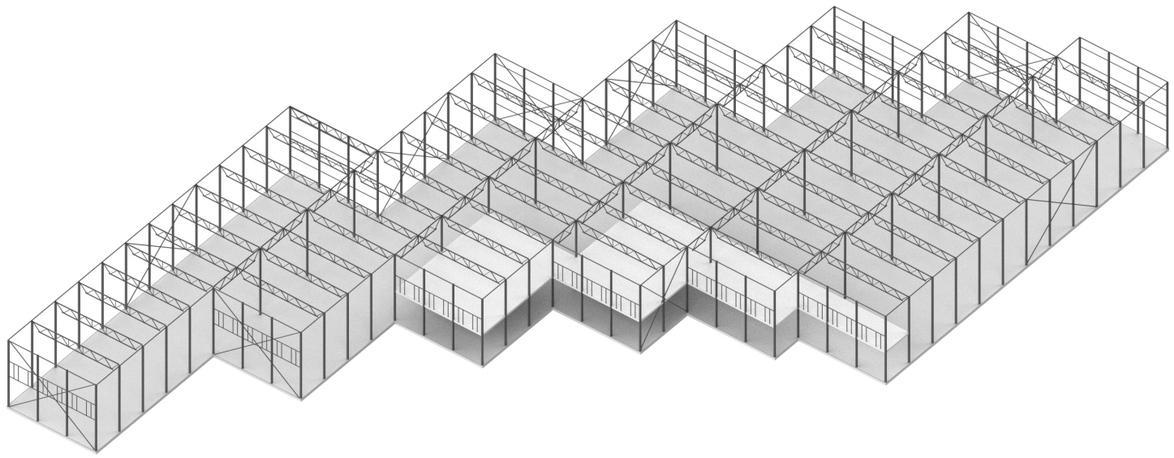
Very large volumes are perceived differently depending on the distance of the observer. I have tried to apply this theme in my façade by identifying what elements or features that respond to each scale. I wanted to create a façade that is relatable to humans standing close by, but also well situated in the landscape.

The next step was to concretize these features and intentions with material and tectonics, and hopefully do this within a realistic budget. The nature of my thesis is not to re-invent the technique of constructing logistics buildings, but rather to study the existing situation and explore possible alternatives with regards to visual impact. Hence, I chose to work with sandwich elements which is a well-established contemporary construction technique. I thought it would be an exciting exercise to make the most out of the standard sandwich panels.

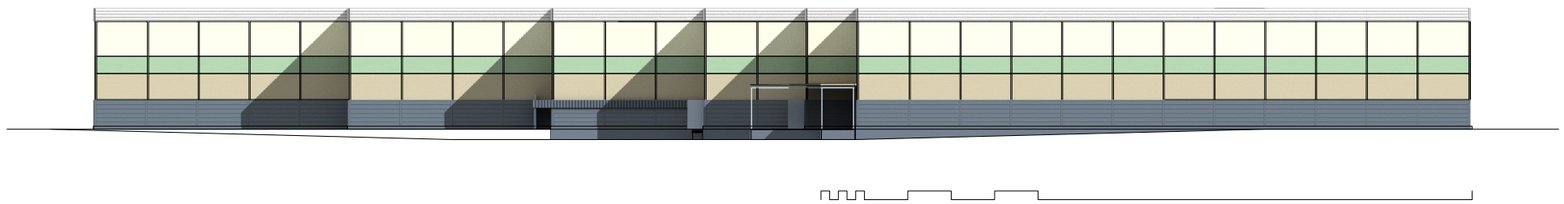
SITUATION PLAN


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A B C D E F G
17100
17100
17100
17100
17100
158400
11700 11700 11700 11700 11700 11700 11700 11700 11700 11700 11700 11700 11700 5850
158800

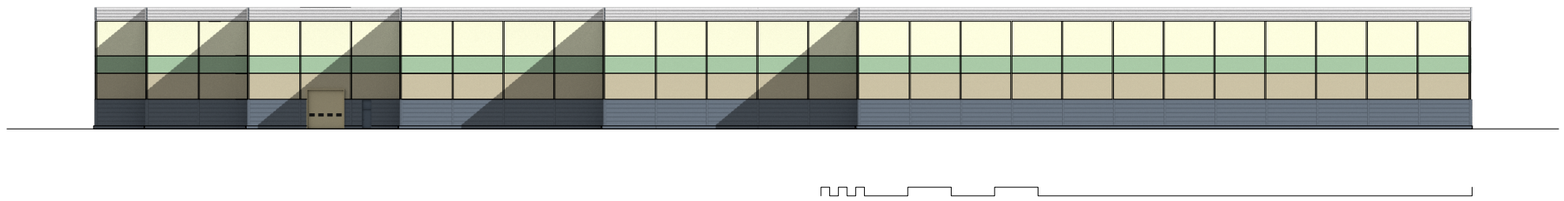
FLOOR PLAN



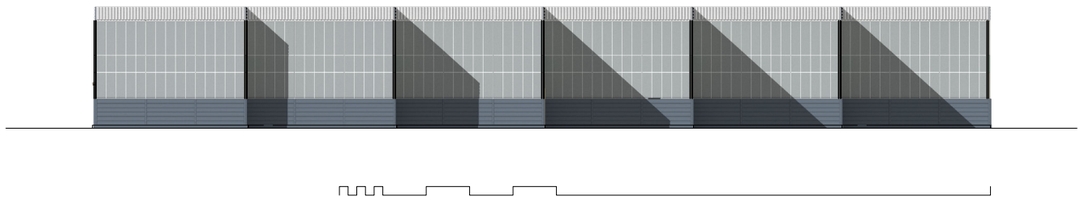
LOAD BEARING STRUCTURE



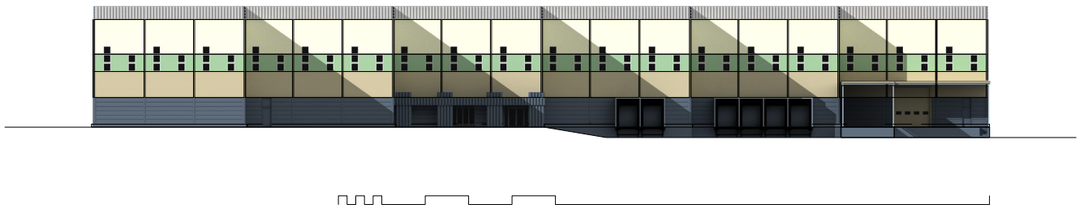
NORTH ELEVATION



SOUTH ELEVATION



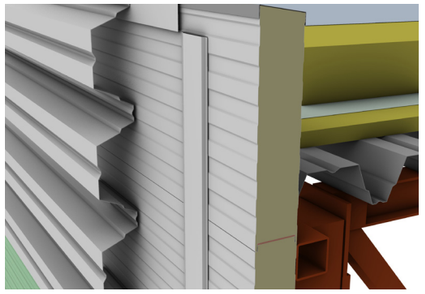
WEST ELEVATION

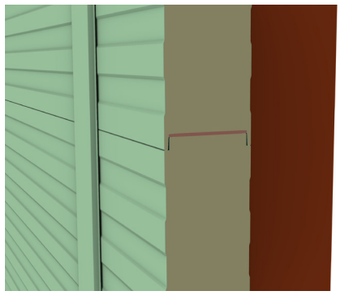


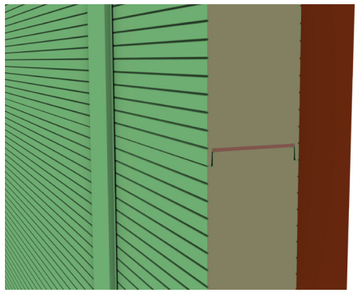
EAST ELEVATION

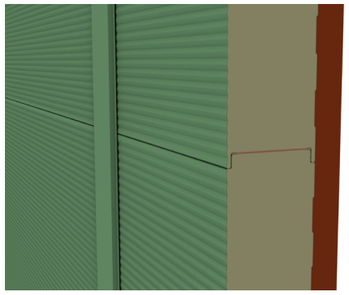
TOPP 12400- 14000 mm
120 mm sandwich panels
Trapezoidal steel sheets

Perceived as an independent color field at long range, a light weight borderline towards the sky. At close range this field gives the façade familiarity by representing an idea of a roof.



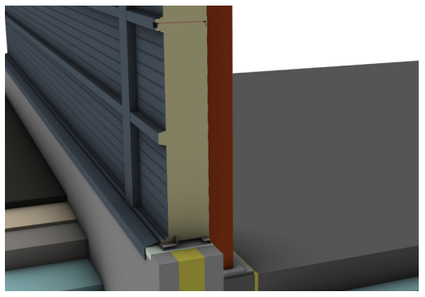






MID SECTION 3400 - 12400 mm
120 mm sandwich panels

The mid field is divided in three different colors with different surface texture of the sandwich panels. In this illustration the colors are correspond to the “heaviness” of the texture rather than the actual colors of the project. This feature is relating to the observers at close range.



BASE 0 - 3400 mm
200 mm sandwich panels

The darker color of the base gives the façade a firm foundation. This field is corresponding to a typical first floor height in an urban context and thus gives the building a relatable scale.

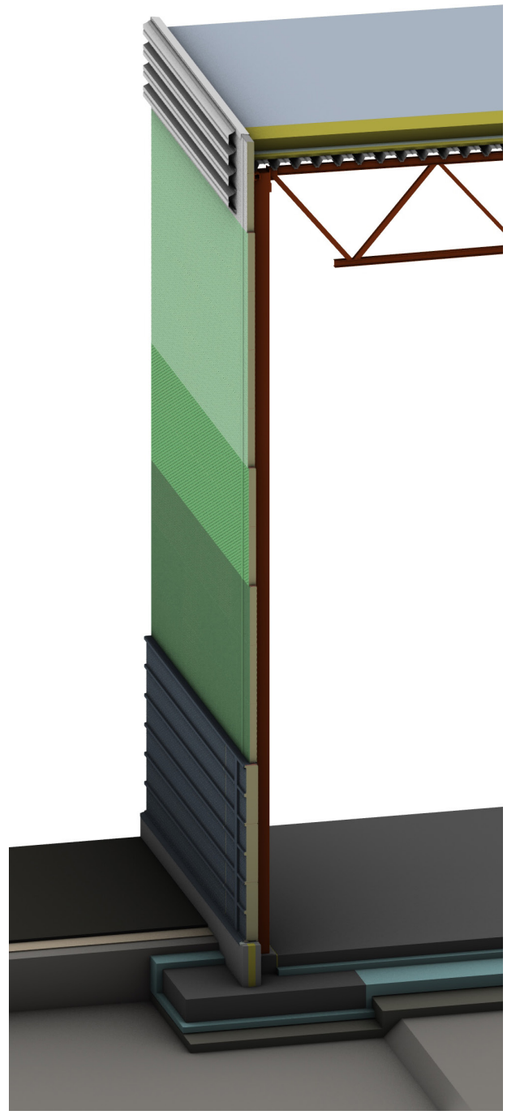


ILLUSTRATION
close range

ILLUSTRATION
mid range

ILLUSTRATION
long range

SUMMARY

SUMMARY

At the beginning of this thesis I identified a visual problem of our everyday environment. Large, ugly logistics buildings are surrounding our cities and negatively affecting spaces many people relate to. Because of their sheer size alone, they become important and should receive more attention.

Examining this typology, I found five main reasons why these buildings represent an environmental problem and some strategies on how to solve them.

NEGLECTED OUTSIDE

A visual improvement does not necessarily mean a huge extra cost in budget. The municipal building authorities needs to demand higher standards.

BREAK IN CONTIOUS LANDSCKAPE

Alternative building shapes should be considered to relate better to a landscape and to achieve shorter facades against roads. This will also give an economic benefit as groundwork will be minimized.

LACK OF HUMAN SCALE

Recognizable elements in the facade like windows, doors and floor indicators makes a building more relatable to humans. Creating smaller spaces around large logistic buildings makes it less intimidating.

FOREIGN OBJECT

Due to its sheer size, a large logistics building is perceived as landscape element and therefor needs to appear grounded to not become an alienated object. Distorting or altering the rectangular shape helps the building to become an integrated part of the landscape.

ANONYMITY

It is a big problem that so many logistics buildings have an anonym, or not recognizable façade. A façade should communicate with the observer by reflecting internal use, structure or other features that helps understand the purpose of the building. By giving the building a distinctive faced it will appear more relatable.

INVESTIGATIONS

In my pursuit of better architecture for logistics buildings I have performed several investigations. I decided to single out a set of individual components that makes up the outward expression of a building. I then studied these aspects separately and evaluated them based on relevant criteria.

I made the following investigations:

Volume: How is a building’s shape perceived in movement?

Outcome: 1) A volume that changes character because of movement is pleasing to the eye and creates a surprise and interest. 2) Movement can create a feeling of participation as the observer discover sightlines that reveals new features of the building. 3) Recognizing a pattern or rhythm in an object when in motion positively affect the impression of the volume.

Position: If the Hydroscand site allows unconventional building volumes.

Outcome: Yes, my investigation proved that it is possible to build buildings of different shapes other than a rectangular and still maintain operational functionality.

Composition: How one can change the impression of the traditional rectangular façade using different composition strategies.

Outcome: 1) Darker, heavier fields at the bottom makes the building appear more grounded. 2) Strong vertical elements direct the focus away from the horizontal box and makes the volume appear smaller. 3) A recognizable scale makes a building more inviting and relatable to humans.

Addition: How additional volumes can improve the visual expression a large rectangular building?

Outcome: 1) Adding volume can redirect the observer’s attention from the rectangular shape of logistics buildings. 2) Creating more complex spatial conditions around a rectangular make it more interesting to observe in motion. 3) This is a promising strategy to improve an already boring façade.

Lights: How can one give personality to a face using widows, while keeping an eye to the budget.

Outcome: Polycarbonate sheets can be used in a successful way to give a personality to a facade.

Surface: An investigation about sandwich panels and other building materials.

Outcome: Sandwich panels seem to be the most cost effective building envelope strategy for logistics buildings.

APPLICATION

Applying the principles learned from my investigations, I have designed a proposal for an alternative logistics building at the Hydroscand property in Lindeberg. With my proposal I have attempted to debate large building volumes within the frames of a logistic building typology.

REFLECTIONS

The main object of my thesis is to make a contribution to good architecture by putting on the agenda a topic that has been neglected for a long time; how to give a good form to large logistics buildings. Through the work with my thesis, I have discovered many opportunities to improve the current state. I have found that it does not need to cost a fortune, even simple measures can improve the situation. I guess it is more a question about attitudes, awareness and rules&regulations and the fact that someone puts the issue on the public agenda. Once the problem of the ugly logistics buildings becomes a public matter of attention, I believe that authorities, architects, and contractors together can facilitate an improvement of the present situation. The inherent framework for a logistics building probably means that they can never become world class architecture, but that is not expected either!? If project owners can and want to spend a lot of time and money, a good architect can make miracles to a logistics building. This of course also applies to other building types. Through my work with my thesis, I have come to realize that even with low budget projects, it is possible to create good architecture, creating a better environment for us all. On my journey writing this paper, I have learned to see better and increased my ability to identify the underlying problems of the unsatisfying architecture of large logistics buildings. At the same time, I have gained a deep belief in and motivation for creating large buildings that are better for human beings – that “meets” humans better. I have received an awareness of unimportant architecture and have seen the importance of taking grips with such buildings. I want to create architecture that meets people where they are and give them the joy of existing in inspiring and soothing spaces.

REFERENCE LIST

- Venturi, R., Brown D. S., Izenour S. (1977) . Learning from Las Vegas : The Massachusetts Institute Of Technology
- Caruso A., (2008). *The Feelings of Things*: Ediciones Poligrafa, S.A.
- Kopacz J.,(2004). *Color in Three-Dimensional Design:* The McGraw-Hill Companies
- Caruso A., Thomas H. (2018). THE FACADE IS THE WINDOW TO THE SOUL OF ARCHITECTURE: VENICE ARCHITECTURE BIENNALE, 2018 : https://drawingmatter.org/the-facade-is-the-window-to-the-soul-of-architecture-venice-architecture-biennale-2018/
- Norconsult Informasjonssystemer AS, Bygganalyse AS (2020). Norsk Prisbok : Online version : https://www.norskprisbok.no/
- Flatby, B.Å., (2009). Kunst i forbifarten:Veikunstens intensjon (Master thesis). Universitetet I Oslo. DUO Reaserch Archive. https://www.duo.uio.no/handle/10852/24795
- Balex Metal. (2020). PU-W-PLUS wall sandwich panels. Balex Metal. https://balex.eu/en/products/sandwich-panels/pu-w-plus-wall-sandwich-panel-polyurethane-core-with-concealed-fasteners
- Designing Buildings Wiki.(2020). Sandwich panel. Designing Buildings Wiki. https://www.designingbuildings.co.uk/wiki/Sandwich_panel
- Statistics Norway (2020). *Innenlandsk transport.* Statistics Norway. https://www.ssb.no/transport-og-reiseliv/statistikker/transpinn