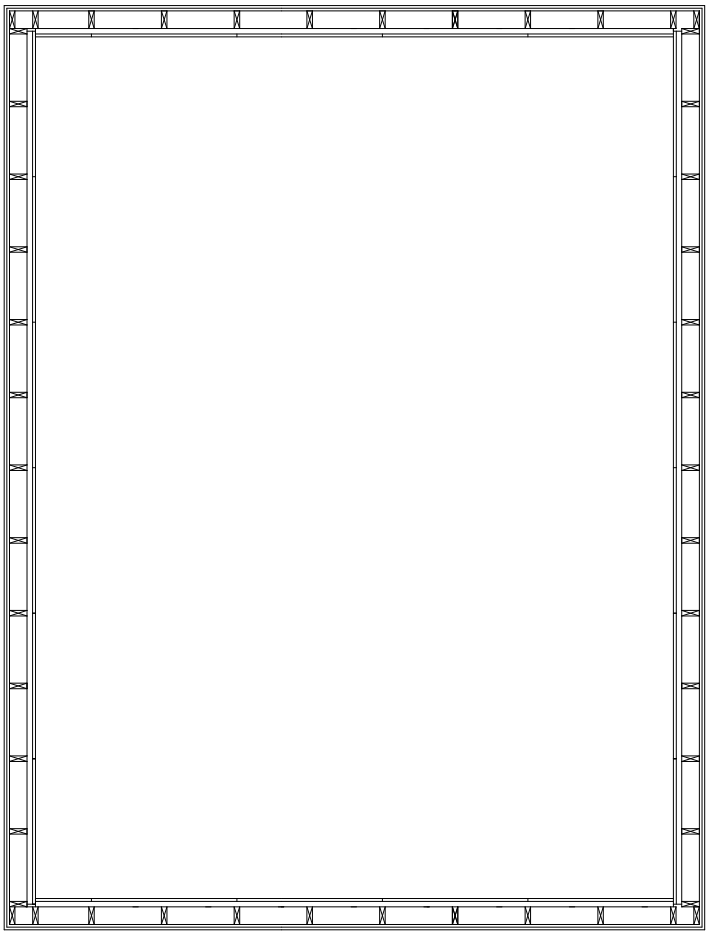

The Mathematics of the Ideal Villa:

The architectural potential of Swedish light-frame construction.

By Vilhelm Anderson
Chalmers School of Architecture
Department of Architecture and Civil Engineering
2025
Examiner: Mikael Ekegren
Supervisor: Björn Gross

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Abstract

This work has examined the light-frame house, focusing on how a house can be built cost-effectively without compromising architectural quality. The relevance of exploring how qualitative houses can be built while remaining cost-effective comes from the notion that the typical prefabricated Swedish house is seldom beautiful nor functional, and that a home is often the largest financial investment a person makes in their life.

The light-frame construction method has long been the most common way of building small houses. One of the major advantages of today's light-frame construction is its flexibility; the building system can be adapted to a variety of designs, and its common use has developed the existing industry furthering its availability and affordability.

Light-frame construction is derived from North America and has evolved into a parallel Swedish tradition. The market in North America, and thus the research on the topic is larger. In this work, ideas have been taken from there and adapted to Swedish conditions: the house can be designed based on the properties of the materials and a conscious thought about how it will be built.

The method to arrive at this has mainly been to iteratively sketch various solutions to find architectural efficiency. Additionally, mathematical analysis of the materials' properties has been used to identify principles that have then been applied. Building references that achieve great architecture with modest means have been analyzed and used in the project.

The outcome of the project is a flexible, detached single-family house of 124 square meters on a medium-sized plot on the outskirts of Gothenburg. The goal of the work has been achieved by answering the research questions through designing a house that harmonizes with its surroundings and is based on rational principles derived from the materials and rational construction methods available on the market. The aim of the project has been to create a house that embodies the Vitruvian principles of firmness, utility, and beauty, and mine: affordability.

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Purpose

Two notions or fundamental assumptions are made to provide a basis for why this work is important.

The first assumption is that the home is an important part of a person's life and that quality living conditions is an integral part of wellbeing. Often, the home is the largest investment made during a lifetime. Therefore, it is of importance that this purchase is good. The home must be of high quality and affordable.

The second notion is that prefabricated catalog houses are neither high-quality nor affordable. They generally have low quality in terms of architectural design or are not adapted to their context.

Since the qualities of the home are important, because homes are expensive, and since few catalog houses are not an alternative, it is crucial to investigate how affordable villa architecture can be created.

Thesis Question

How can a high quality, cost-efficient, light frame construction house be built by basing the design on maximizing the potential of the material and the use of labor?

Objectives

The objective of the thesis is to develop principles and concepts for a method of designing houses cost-effectively. These principles and concepts are crystallized in a finished project. This project is intended to demonstrate that good and exciting architecture can be created based on a rational analysis of the real properties of commonly avaliable materials.

Methods

This thesis has primarily been carried out through research by design.The project is developed through iterative sketching and drawing, as well as through physical models.

Built references has been used to find architectural approaches to the design challange. These references has been analysed and i some cases visited and in relation to the thesis question on how they use minimal means to create a coherent architecture.

Analyses of the big Swedish hardware stores merchendise has been conducted to find principles of how construction might be conducted economically and general mathematical calculations has been made to get numbers on how different solutions compare with each other.

Lastly, literature research has been used as as a complement, exploring relevant studies on different framing methods and their advantages and disadvantages.

Delimitations

The thesis does not adress issues in the construction process that are not within the architect's area of responsibility. For example, I will not develop a method for finding affordable plots or identifying potential plots that can be subdivided. That said, the work is to some extent based on expanding the architect's responsibility to include structural efficiency and so on. The scope is to extend the architect's responsibility into a newly defined area.

The work is based on light timber framing. This is because it is the most common and considered the cheapest way to build single-family homes in Sweden.

Although the project has focused on available materials, It does not focus on how and where to get the cheapest price for the materials. This is because building material prices fluctuate. This makes the project's insights resilient to future material prices. As long as nothing drastic happens, the project will remain relevant.

The project does not adress reuse of materials, as that would make the project dependent on the specific materials that are assumed acquireable.

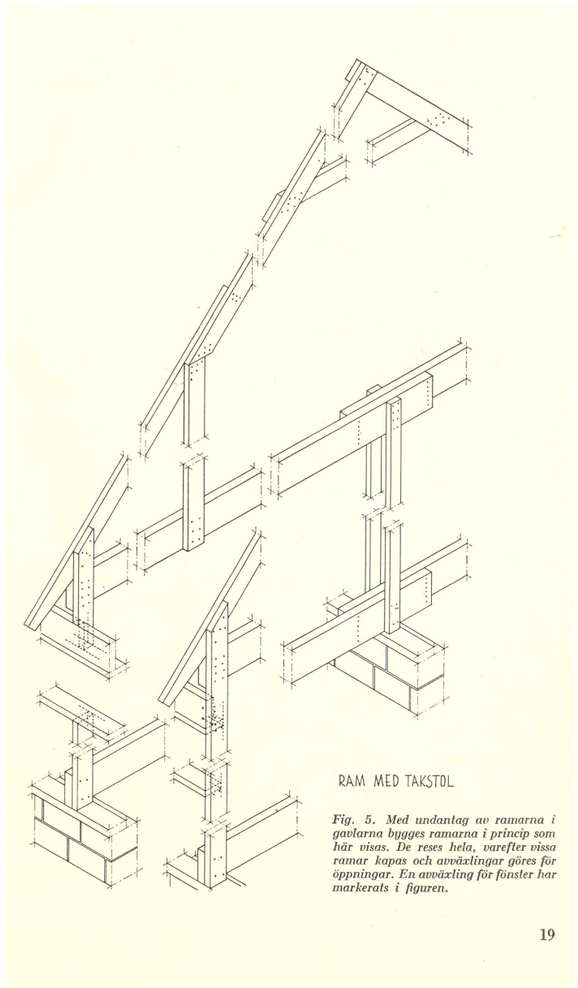


Image 1

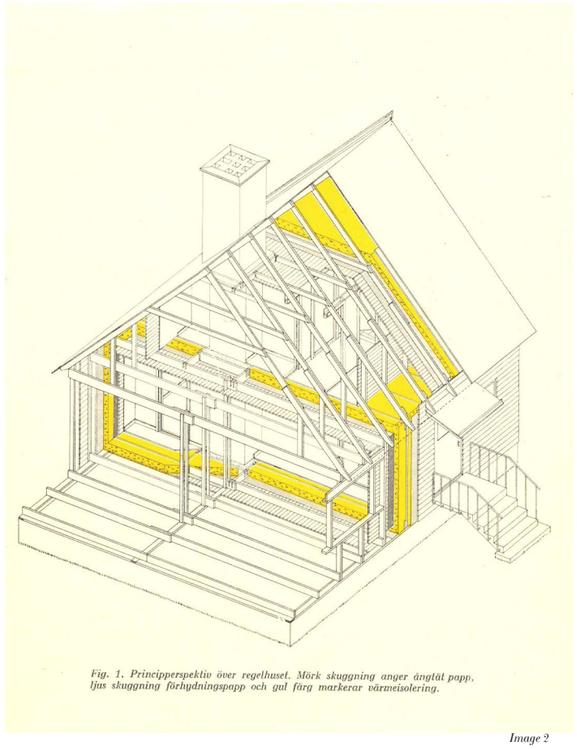


Image 2

Starting point of Swedish Light Timber Framing

In 1953, the Kungliga Bostadsstyrelsens Skrifter published *Regelhuset: Ett Ekonomiskt Handbyggt Trähus* (1953), a standardized construction design intended to replace the more common and labor- and material-intensive plank houses. The prerequisite for using this construction technique for residential houses in the cold Nordic climate (timber framing had long been used for unheated buildings) was that insulation materials had begun to be industrially produced.

The standardized design consists of a series of frames erected sequentially, first assembled on the ground. These frames were constructed using shorter studs that were overlapped and nailed together. They were then connected with blocking and exterior studs. The Bostadsstyrelsen also suggested, which was unusual in Sweden at the time, using horizontal wood paneling as the most rational facade construction.

With this publication, the lightweight framing construction method was widely introduced in Sweden. This transformed the sawmill industry and marked the beginning of how the lightweight framing tradition that Swedish homes are built.

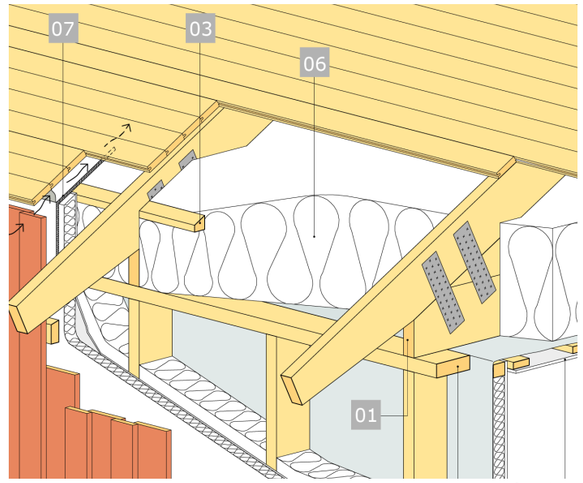
Svenskt trä

Since the 1950s, construction methods have evolved, though they still operate within the same building tradition due to the forestry industry's slow adaptation.

Träguiden and *Att välja trä*(2020) is an initiative by Svenskt Trä that compiles construction recommendations for lightweight frame houses. Svenskt Trä is a Swedish industry organization representing most of the major lumber companies. Their construction guidelines are widely followed and provide a summary of how most Swedish builders actually construct small homes. Other methods certainly exist and are used, but in this work Träguiden's construction examples is often used as a starting point.

Träguiden suggests a platform framing structure, meaning a wall is built with a top plate onto which floors or roof trusses are placed. This method was criticized by the Royal Housing Board in 1953 for its inefficiency and on-site work hazards. Despite this, two main advantages make platform framing the most common approach in both North America and the Nordic countries. The first advantage arises when shorter studs are cheaper than longer ones (as was historically the case, especially in North America), since platform framing does not require long studs like balloon framing or frame-framing do. The second advantage is that it's a general system. There's less need to adapt the structure specifically to window placements and vice versa. This system allows one part of the house to be built without needing to consider the entire building.

The second advantage is also a disadvantage of the construction method. Since the solutions are general and meant to work anywhere in any house, they are by definition non-specific and do not solve the specific task in the best possible way.



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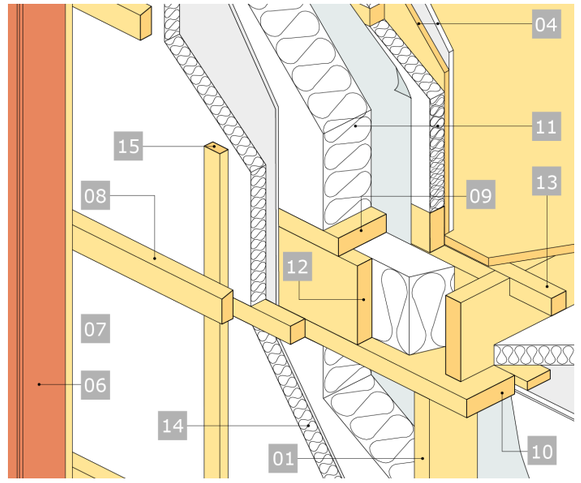

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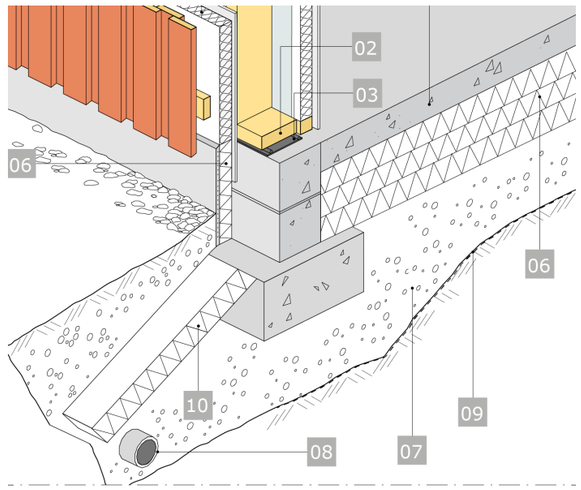


Image 5

Another source is specifically the *Advanced Framing Construction Guide* (2016) and, more generally, its author, APA: The American Engineered Wood Association's various publications. This organization is similar to Svenskt Trä but also conducts research on efficient wood construction methods. The guide contains numerous in-depth proposals and comparisons of construction methods to save lumber, reduce thermal bridging, and minimize labor.

The American Engineered Wood Association conducts research on the efficiency of light-frame constructions at a level unmatched in Scandinavia. This is expected, given that significantly more wooden houses are built in North America than in the Nordics. This research is adapted to North American measurement systems, warmer climates, available materials, regulations, and labor costs, which means it is not directly applicable in a Swedish context. A significant part of this work will involve translating these American principles so that they work in a Swedish context.

The research projects they conduct aims to identify principles that carpenters can use to build a house more easily. Often, this involves small adjustments to window placement and wall lengths. It is not presented as a way to design more efficiently, but the ingredients for principles on how to design more efficiently are embedded in this work.

Below is an image showing one of the principles for how efficiency can be achieved. On the left is a conventional American stud wall, and on the right, an "advanced framing wall". Two things are especially worth noting for a designer. First, in the image on the right, the window has been moved to require as few vertical studs as possible, meaning that the window placement and construction are in harmony. The second thing worth noting is that there is only one top plate. This only works if you ensure that the vertical loads on the wall land directly on the wall's vertical studs. This places additional demands on the designer and increases the design's complexity.

Advanced Framing Construction

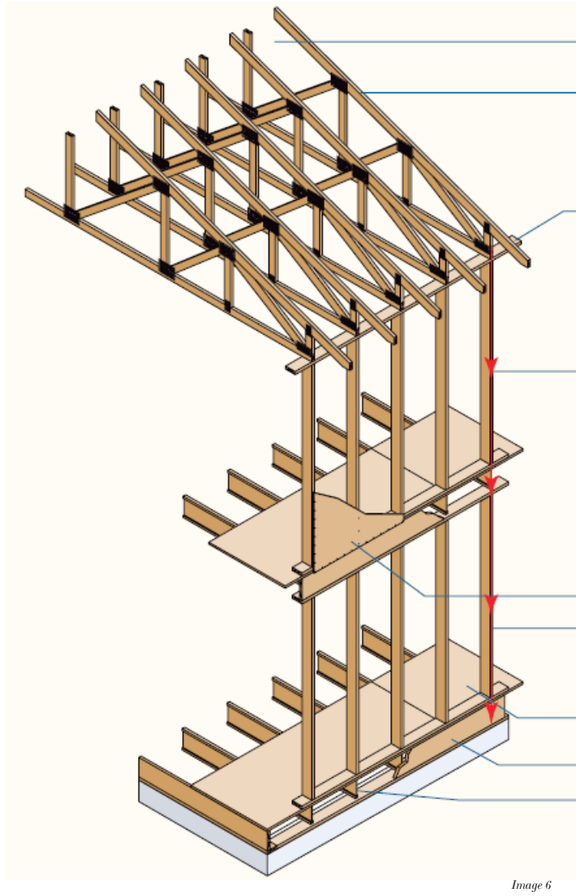


Image 6

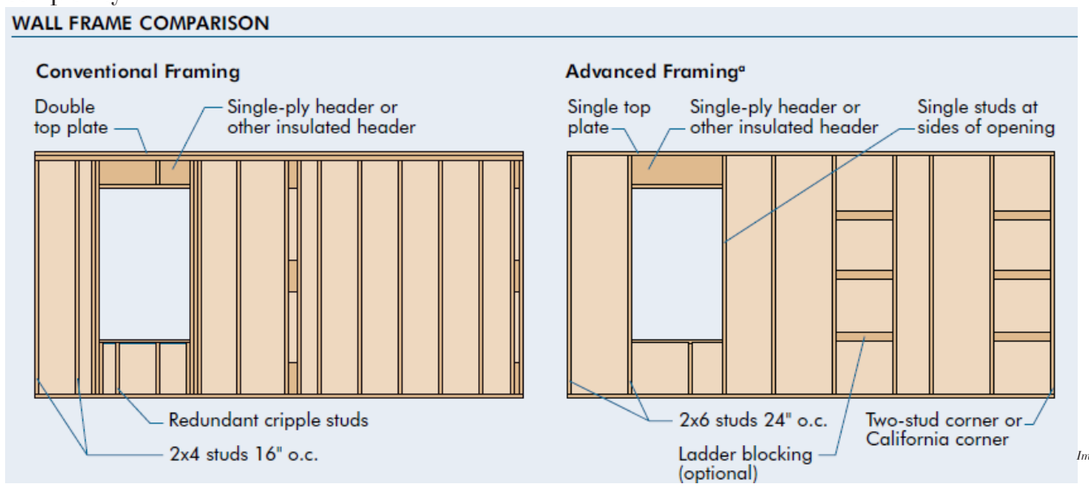
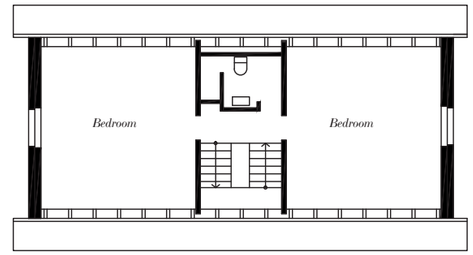


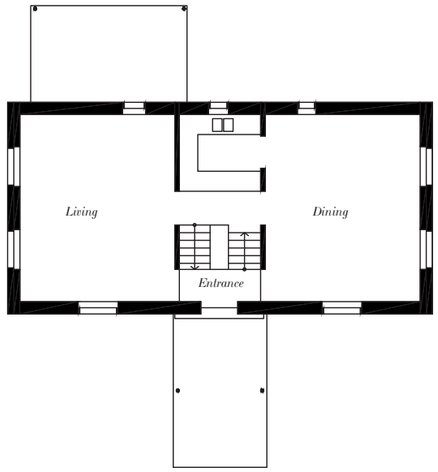
Image 7

Main Facade East

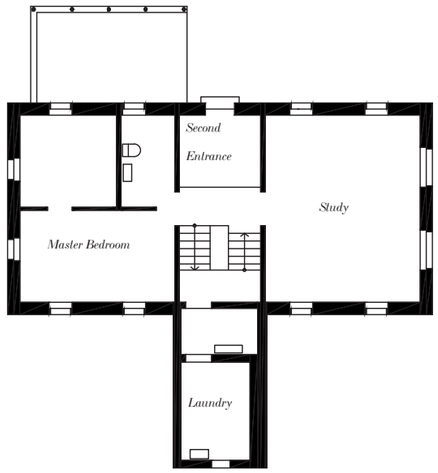
Scale 1:100



Plan Third Floor



Plan Second Floor



Plan First Floor

Scale 1:200

Built References
Das Haus
Itingen
Michael Alder
1984

The House is exactly what the name suggests. It is a house that looks like a house that looks like a house. It stands in Itingen, just outside Basel, in a residential area with tightly spaced houses. The facade shown above is the front of the house and what is visible from the street. The plan is as simple as possible, with the exception of a laundry room and storage spaces that protrude on the sides to create areas for the two entrances.

The layout, as a concept, consists of two rooms, one facing the street , one facing the garden, and functions between. Toilet, kitchen, entrance, and stairs are located in the building's core. A half story shift at the center of the house adds a small dose of complexity.

Large windows are placed on the non-load-bearing gables, where there is a view, and small windows, which I assume, are inserted on the long sides between the load-bearing structure to avoid interfering with the construction or creating privacy issues from the nearby neighbors.

Das House's attitude of objectivity, rationality, and simplicity demonstrates, perhaps even more clearly than the other references, how great architecture can be achieved with minimal means.

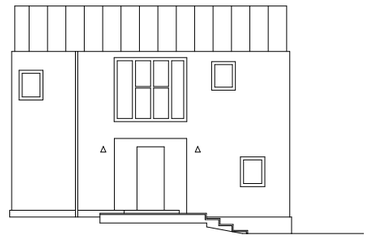
Built References
Fritidshus 1
Johan Celsing
1994

Image 8

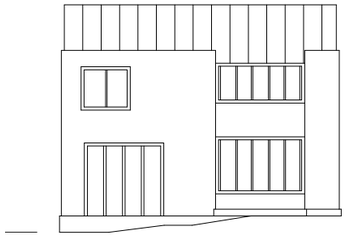
Celsing's Vacation House in Norrtälje has a simple cubic volume, is painted red, and features windows in light colors. The roof is made of metal, and its length, which is slightly shorter than the house itself, accentuates the distinction between the roof and the walls. Inside, there are differences in height both on the ground floor and in the joists, creating a hierarchy between the rooms. On the ground floor, there are two halls: one public, leading to the livingroom and stairs, and a more private one leading to the bathroom, utility entrance, and kitchen. From the kitchen and entrance hall, you reach a large living room, which is divided into several spatial zones through variations in height, walls, and windows.

Image 9

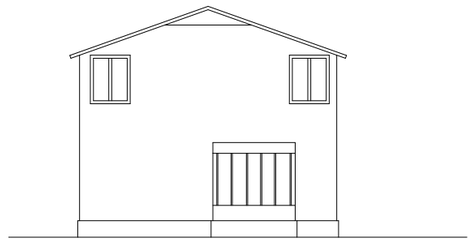
I am impressed by how well-considered the floor plan is. It embodies a complex idea of what family and social life in Sweden looks like today. For me, this is primarily a reference for the layout of a living space. Also, the handling of details feels honest and contemporary. The house does not shy away from being part of a Swedish "slab-on-ground" and exaggerated sheet-metal tradition. Instead, it embraces and makes something of it.
I note that the walls are folded to create a buffer-zone between hall and living room. Which instead of creating a thick wall adheres to the logic of wooden building.



Facade South

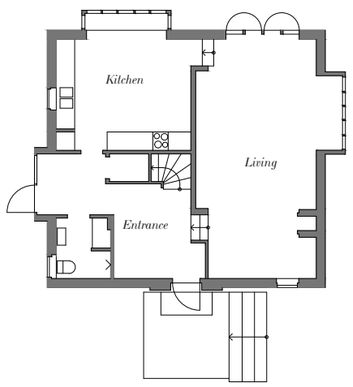


Facade North

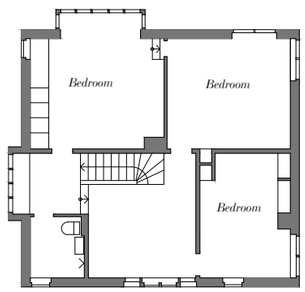


Facade East

Facade West



Plan Entrance



Second Plan

Scale 1:200

Image 10

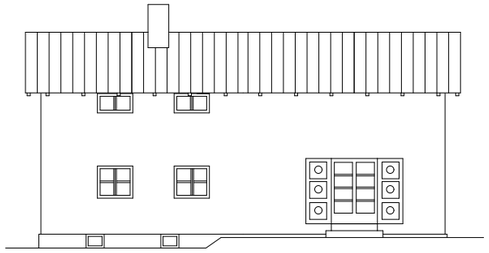
Built References
Villa in Lidingö
Sven Markelius
1925

Bygge och Bo was a housing exhibition held in 1925 on Lidingö. The purpose was to create a new modern residential area, based on a large competition in which many now well-known Swedish architects participated. Sven Markelius designed three houses and the urban plan for the exhibition.

One of these houses is the one to the left in the picture. It is a wooden house with a basement, and the volume is simple, based on the characteristics of wood. It has three bedrooms plus a maid's room. The floor plan is clearly divided between servant and served spaces. The hallway, living room, and dining room are distinct and straightforward rooms, with hidden passageways leading to the kitchen area of the home.

The house's volume and detailing are clear and simple. The complexity of the project comes from the fact that one moves via a staircase around the house, through a private garden to reach the entrance, and into the living rooms that again look out over the street.

The value of this project for the thesis lies in the simplicity and elegance of the means used to create a refined house. It shows that one doesn't need to resort to tricks to achieve great architecture. All of the house's defining features are clear and difficult to question.



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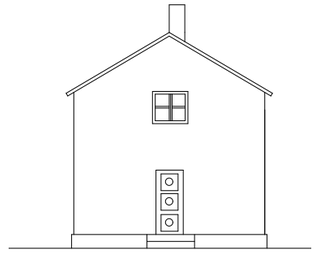
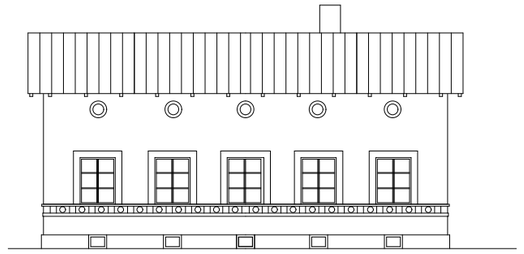
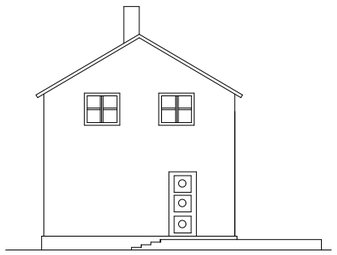


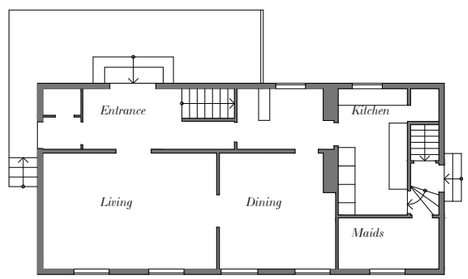
Facade West



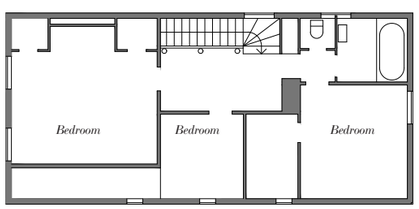
Facade South



Facade East

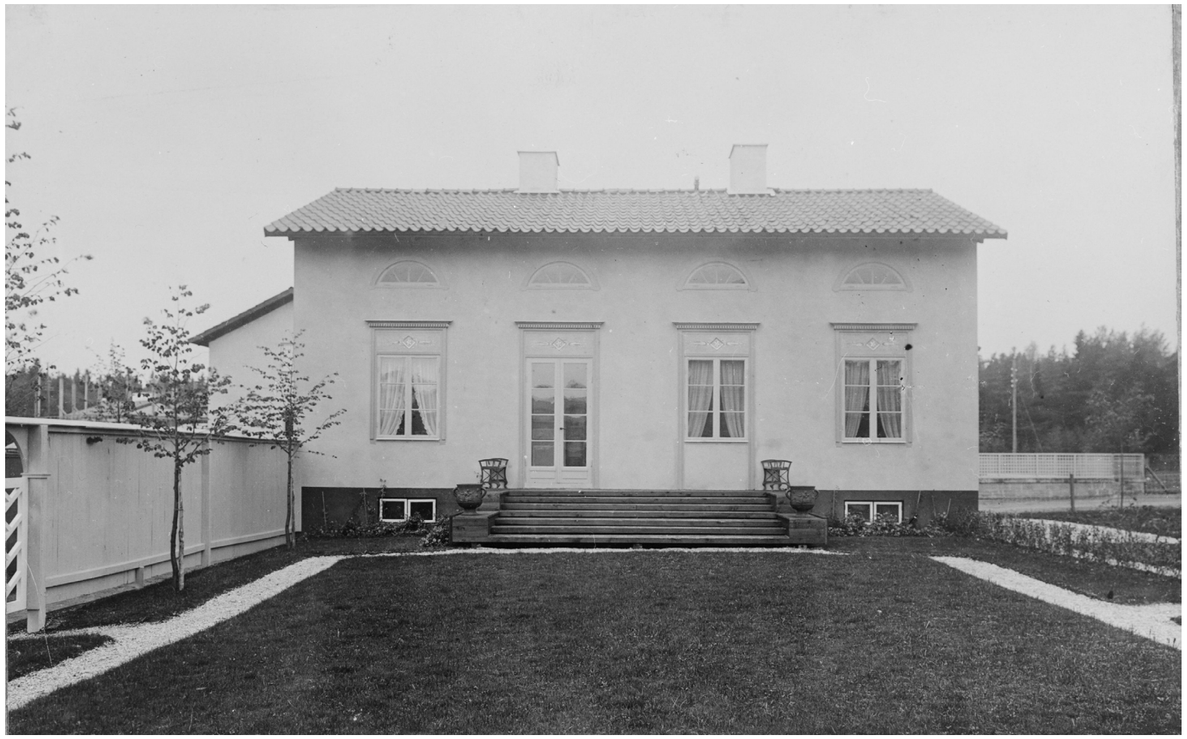


Plan Entrance



Second Plan

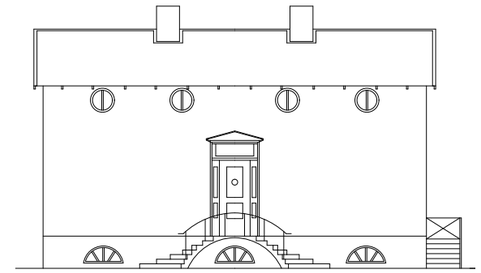
Scale 1:200



Built References
Lidingö Villa
Tage William-Olsson
1925

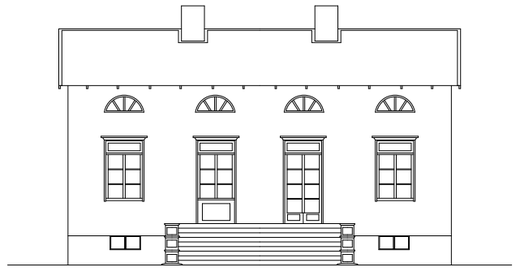
Another house belonging to the same housing exhibition is Tage William-Olsson's house. It is not as simple as the previous one, but just as elegant. The house is positioned slightly askew from the street, which gives an informal contrast to the otherwise extremely strict façade treatment. The angled hallway with the staircase animates the wall and leads the visitor straight through the house to the garden stairs on the other side. Two larger social rooms face the garden. A very narrow staircase allows the maid's room to be on the upper floor, which gives more space for the living rooms on the ground floor.

Like Markelius's villa, this project is interesting for its simplicity and the economy of elements used to create a big effect. The angled hallway is an alien element that enlivens the whole house, demonstrating the power of one strong feature. The balance between formal and informal is finely tuned in this project.



Facade South

Facade East



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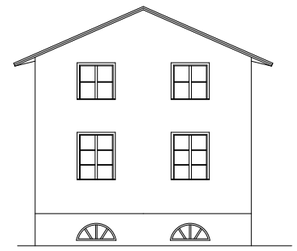
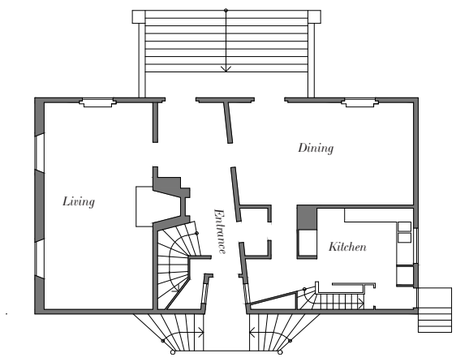
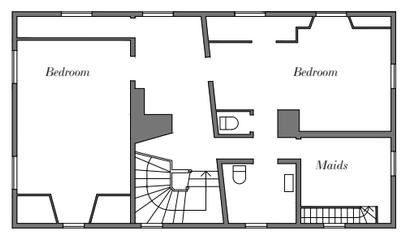


Facade West



Plan Entrance



Second Plan

Scale 1:200

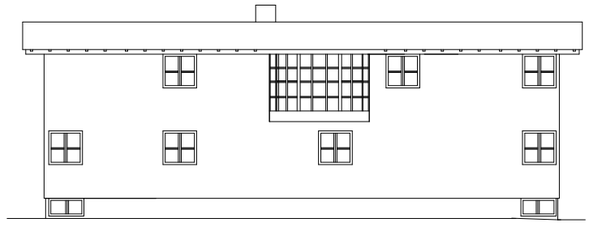
Image 12

Built References
Villa Drake
Jan Gezelius
1968-1970

Villa Drake by Jan Gezelius was built between 1968 and 1970. In a Swedish late modernist tradition of the "Million Program," the house stands out with its narrow body. With this house, Gezelius demonstrates the simple elegance of a room with windows on three sides, contrasting with the then-common 1.5-story houses. The rooms at the ends of the structure are serviced by the rooms in the middle of the house. On the second floor, a third bedroom in the middle of the structure is compensated by having a large bay window.

Image 13

When I look at the façade drawings of the house, I am surprised. The same window type is repeated 31 times, and to me, the window arrangement feels completely disharmonious in the drawing. But when I look at photographs of the house, I see a harmonious and beautiful building. I believe the strong volume of the structure and the detailing either allow for or make a virtue of the chaotic arrangement of the windows. It is precisely the detailing that makes this house special. The combination of the roof's robustness, perhaps coarseness, and at the same time lightness and elegance is incredible.



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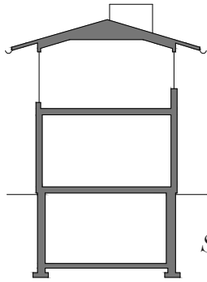
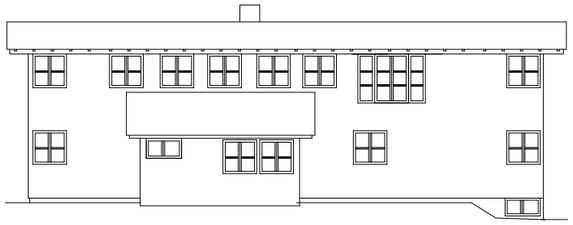
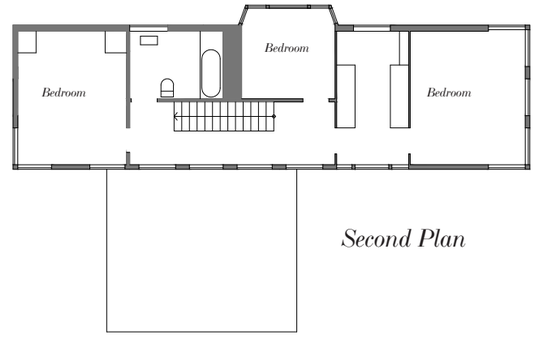


Section

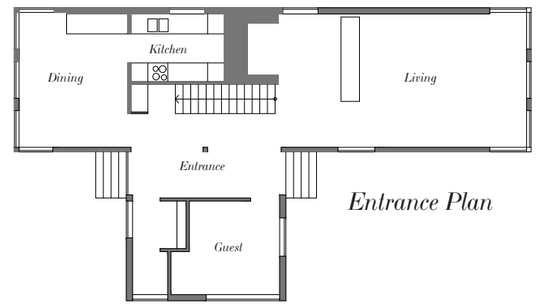


Facade South



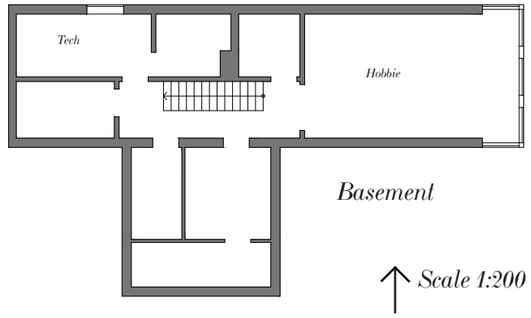
Second Plan

Facade East



Entrance Plan

Facade West



Basement

Scale 1:200

The Plot

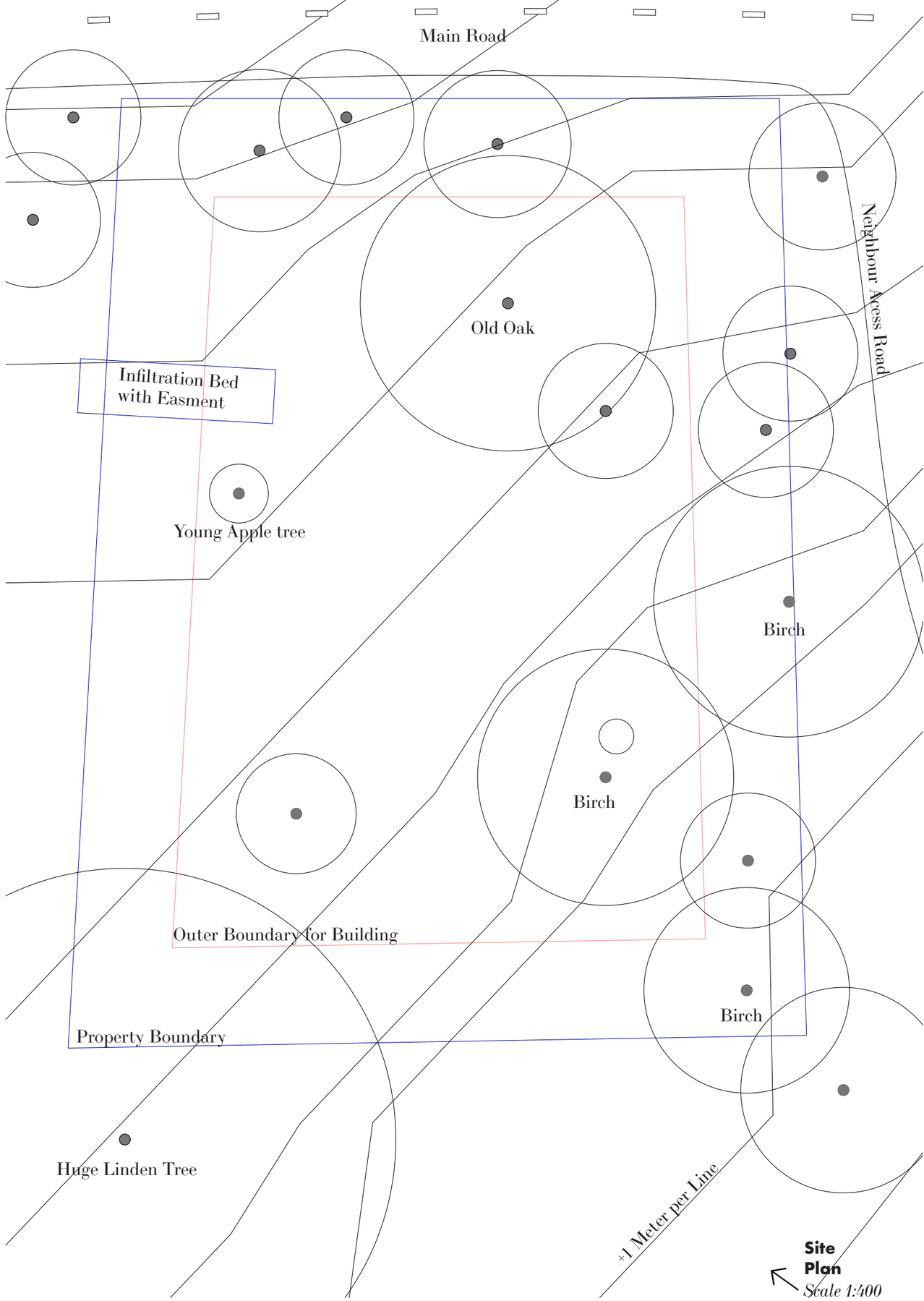
Image 16

The plot is located in Bårhult, just west of Landvetter in Härryda municipality. The project site was chosen for its typicality and commonness for southern Sweden. It is a small garden town in a large sloping clearing within a rolling landscape of mixed forest-covered hills and valleys. The land slopes downward to the south. In the clearing, there are 12 plots, one of which is for sale. On the other eleven plots, there are simple one-and-a-half-story single-family houses made of painted wood with felt or tile roofs. Most plots are developed with a garage building, a small guest house, and terraces. The gardens are large, with enormous deciduous trees and are well-maintained.

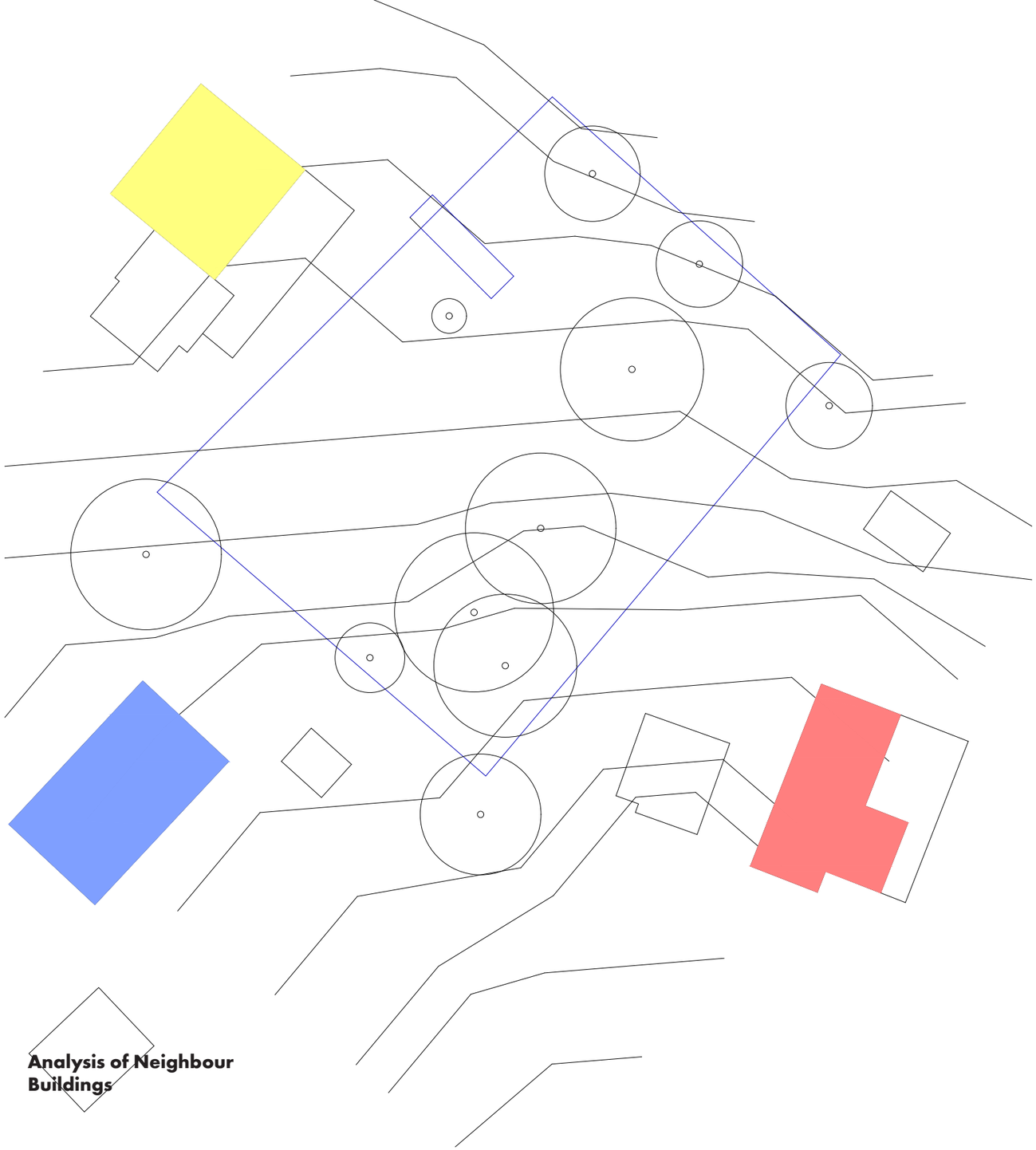
To the west, separated by Partillevägen and forest, lies a large industrial area with manufacturing and warehouse facilities. To the south, Landvetter Lake is nearby but separated by Highway 40, which takes residents of Bårhult 20 minutes by car to Gothenburg or 70 minutes by bus via Landvetter. The car is a necessity in Bårhult. To the north and east, there are large forested areas.

The plot itself is subdivided from the adjacent plot to the west and is currently (as of October 11, 2024) for sale for SEK 1 600 000. It covers 1 380 square meters. There is no detail plan in the area. The plot slopes to the south, with a height difference of 7 meters from the highest to the lowest point. According to maps from the lantmäteriet, the ground consists of sandy moraine.

On the plot, there are three large birch trees and an old oak tree, two newly planted apple trees, and bushes in the southeast. In the middle of the plot, there is a infiltration chamber with an easement for drainage for adjacent buildings.



Site Plan
Scale 1:400



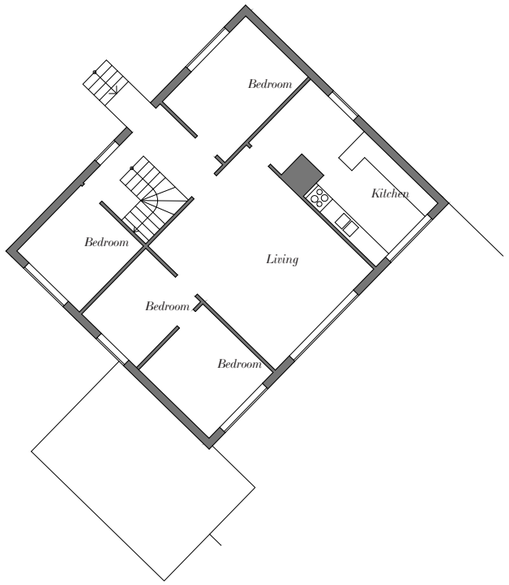
Analysis of Neighbour Buildings

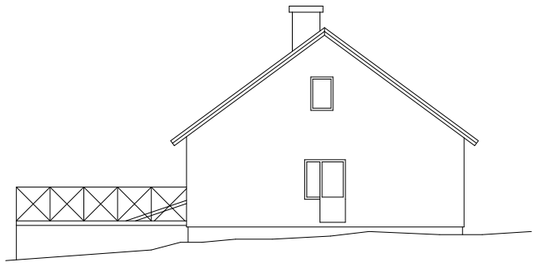
Scale 1:400

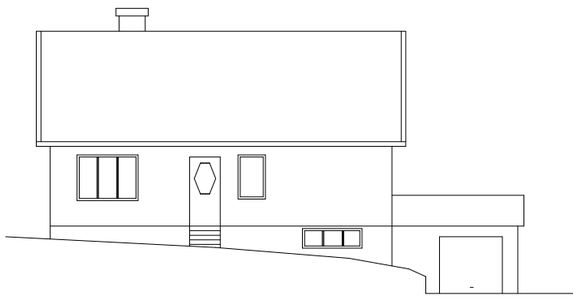
Neighbour to the North West

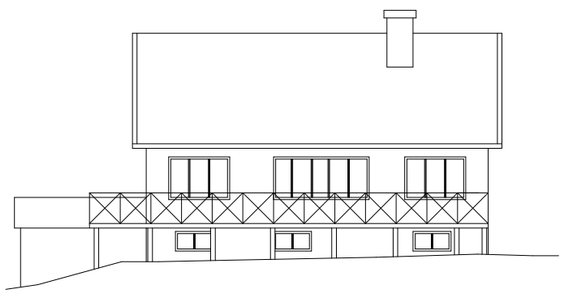
The neighbor to the northwest is the property from which our plot was subdivided. The house is relatively close and situated at a higher elevation than our lot. It's a yellow one-and-a-half-story and cellar wooden house that seems to have been remade from an older house in 1968.

The entrance and parking area are to the west, facing our plot, but the house's main living areas overlook a spacious terrace that faces our lot. Our house must be designed with this terrace in mind. Around the property, there is a dog fence bordering our house. The largest contiguous garden is to the north.







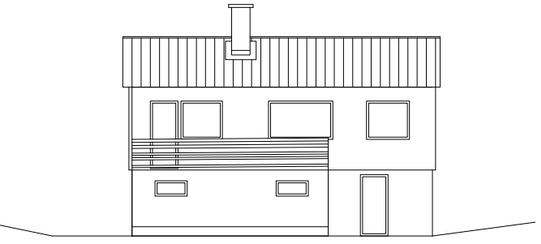


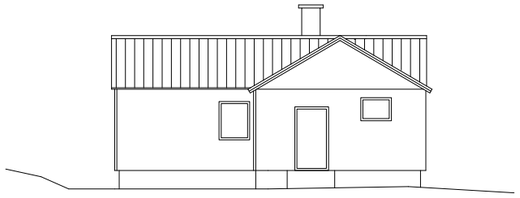
Scale 1:200

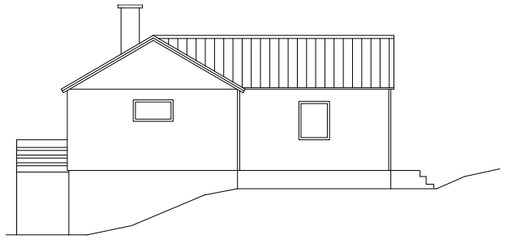
Neighbour to the South East

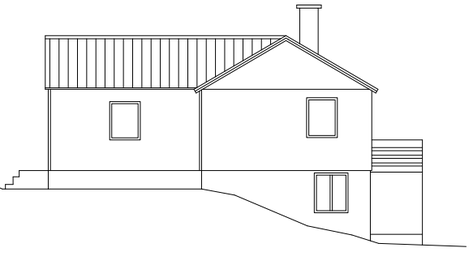
The neighboring house to the southeast is on the other side of an existing shrubbery and an access road. It is a small red two-story wooden house from 1988 and has the character of a Swedish holiday-cottage (fritidsstuga). The plot is heavily terraced, with the entrance on the north side almost below ground level, while the basement on the south side has large windows. This means that the house itself, and especially its windows, are hardly visible from our lot. Only one room has a view towards the northwest. Otherwise, the house is oriented towards a terrace and a garden to the south.

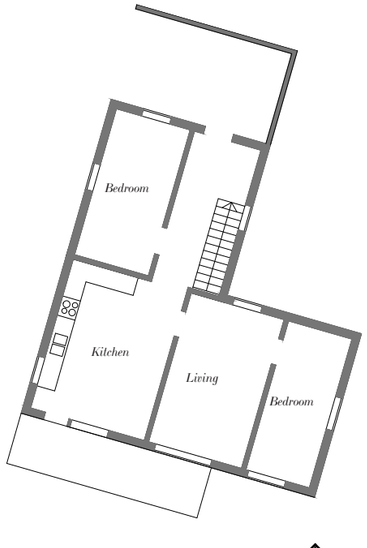
The driveway to the plot is adjacent to our lot where the ground is not as steep. The same applies to our plot, which may make it most practical to build a similar road but on the other side of the plot boundary. Doing so would also place the parking spaces next to each other.









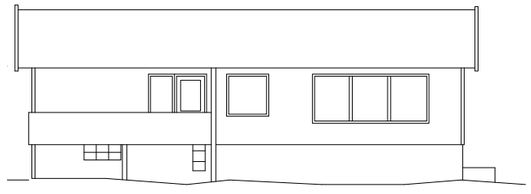


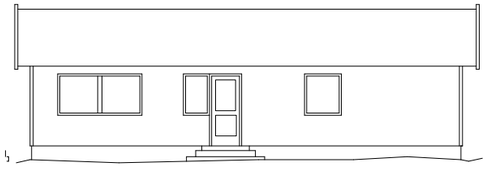
↑ *Scale 1:200*

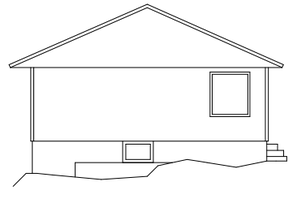
Neighbour to the South West

The neighboring house to the southwest is a gray and black single-story wooden house with a basement. Like the neighbor to the northwest, it has undergone a major renovation that gave it its current appearance. This last occurred in 1994. The basement is exposed to the southeast, where the land is terraced down to a low-lying garden. A playhouse, a significant slope, and a now low hedge limit the view into our garden. Only one window faces northeast, but it's the kitchen window above the sink, where someone is likely to often stand and look out.

The house's placement in the north of its plot is designed so that the garden is both spacious and private. This quality should be respected in the design of our house, especially since it provides our plot with an unobstructed view to the south.







↑ *Scale 1:200*

Insulation Thickness

					Price per sqm. wall				Price per sqm. wall over 20 years			
Insulation (mm.)	Kr/0.6sqm.	kr/sqm.	kWh/yr.	kWh/20 yr.	Fix+Direct	F+Direct	Fix+HP	F+HP	Fix+Direct	F+Direct	Fix+HP	F
145	114	189	28	560	1120	286	246	63	1309	475	436	
170	130	216	24	480	960	245	211	54	1176	461	428	
190	167	278	22	430	860	219	189	49	1138	497	467	
215	183	305	19	378	756	193	166	43	1061	498	471	
240	186	310	17	338	676	172	149	38	986	482	458	
265	202	337	15	306	612	156	135	35	949	493	472	
290	222	370	14	280	560	143	123	32	930	513	494	

The Most Optimal Wall Thickness
Above is an export from the Excel sheet that calculates the economically optimal insulation thickness based on the scenarios of fixed/flexible electricity price and geothermal heat pump/direct electric heating. The calculations show that even with direct electric heating, if the house's electricity price is fixed, it has historically been economically best to build thinner walls.

In Sweden, the need to insulate the light frame house is so large that the thickness of the outer wall does not depend on the dimensions of the supporting structure to carry the house, but rather to accommodate enough insulation. The economically optimal wall thickness has been calculated here based on different parameters.

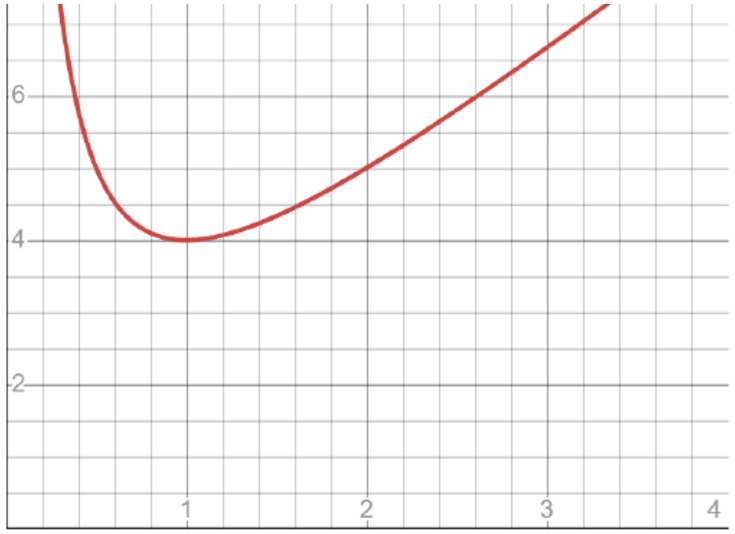
The wall typically has two layers of insulation on each side of the vapor barrier. One layer is between the standing, load-bearing studs, and the other is in the installation layer, which allows for running wires through the house without disturbing the vapor barrier or the wall's studs. This means that only a limited number of different insulation thicknesses are rational to build. In this calculation example, it ranges from 145 mm to 290 mm of insulation.

The price per square meter of wall surface is only the material cost for insulation and studs. Therefore, the fact that it likely takes more time and is thus more expensive to build a thicker and heavier wall is excluded here.

In the calculation example, two different values for electricity prices have been used according to the state-owned Vattenfall (vattenfall.se). One value for fixed electricity price (Fix in the sheet above) and one for flexible electricity price (F in the sheet). The two values are averages from the last five years, with electricity prices having increased significantly in recent years, which affects the calculations. These figures are historical, and since it is impossible to predict future electricity prices, there is no certainty that comparable figures will hold in the future.

The cost of the heat itself is also split into two. One calculation was made for the price if direct electric heating were used (direct in the sheet above), and the other if a geothermal heat pump were used (HP in the sheet). To the far right, there is the construction cost and heating cost calculated over 20 years. This is because the estimated lifespan of a typical geothermal heat pump is about 20 years. The cost of installing the geothermal heat pump (300 000 kr) and its efficiency (400%) (bygghemma.se) are also included. The installation cost, efficiency, and expected lifespan come from bygghemma.se, which sells geothermal heat pumps. The calculation does not take into account that it is likely much cheaper to replace the geothermal heat pump after 20 years than the initial cost of installing it.

According to government regulations, there are requirements for the maximum total U-value of the house, but only target values for individual elements of the house. A high U-value for the walls can be compensated with a lower value for the roof, foundation, windows, etc. The foundation and roof are cheaper to insulate because there is no need for studs between the insulation to extra-insulate.



The Relationship Between the Area and the Difference between the two sides of a rectangle
The longer the house is, the more wall is needed to cover the same amount of area, thus if a rectangular house is choosen, the most effective wall to area ratio is 1:1. But the relationship area and difference of length of sides is not linear. This calculation shows that when the relationship between the two walls area is smaller than 1:sqare root of 2: the cost is smaller.

Calculation
The formula for how the price difference depends on the house's length versus width is:

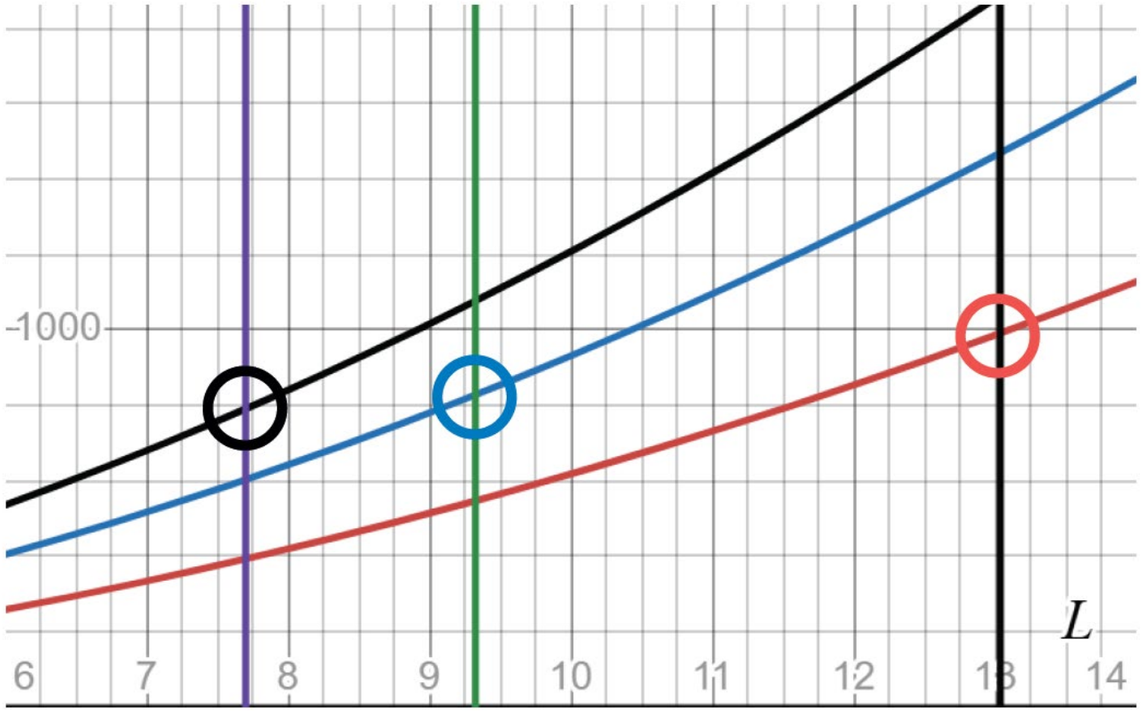
$O = 2(L + (1/L))$

Where:
O = perimeter
L = length of one side
The area is constant (L * L = 1).

Comments
The formula shows the relationship that the larger L is, the larger O becomes. The relationship is exponential. Small changes in L have a minor effect on O compared to large changes. In other words:

The derivative is:
$o' = 2 - (2 / L * L)$

The square is the optimal formula for low perimeter per area. Small deviations from the square are more forgiving than large deviations. When L approaches the square root of 2, the length of the sides expandes more quickly.



Calulating Price for Different amount of Floors
A seemingly simple question: What amount of floors is optimal? The calculation shows that materials for a one story building is aproxamatly 20% more expensive than that of a two or three story house. The two and three story houses have an comparable sqm. price and the three story house is 5% cheaper per cubic meter.
The graph shows the function where Y is price per cubic meter and X(L) I s the lengt of the square plan house. The Black circle shows the intersection for where three stories have 170 sqm, Blue is for two stories and Red is for a one story house.

Variables
V=Number of Levels
b=Width
L=Length
h=Height
Pt=total Price
Py=Price for outer wall per m2=616kr per m2
Pa=Price for foundation + roof per m2=2443kr per m2
Pv=Price for intermediate floor=616kr per m2
A=bL
Price come from calculation without taking worker into consideration 2025-01-29

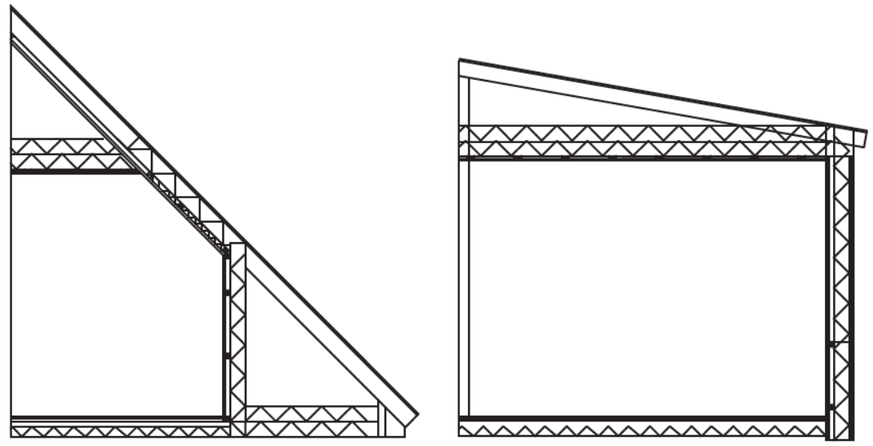
Formula for Calculating Price:
Pt=Pa*Lb+Pv*VLb+Py*2h(L+b)
Formula for calculating square meter price
Pt/Lb(V+1)=(Pa*Lb+Pv*VLb+Py*2h(L+b))/Lb(V+1)
Formula for calculating cubic meter price
Pt/Lbh=(Pa*Lb+Pv*VLb+Py*2h(L+b))/Lbh
For all calculations Lb=170 (area)

One Floor Optimally Gives
If h=2.8
L=b=13.
Total price 471 273 kr
Sqm. price 2772 kr
Cubic m. price 990 kr

Two Floors Optimally Gives
If h=5.6
L=b=9.2
Total price 395 500 kr
Sqm. price 2326 kr
Cubic m. price 826 kr

Three Floors Optimally Gives
If h=8.4
L=b=7.7
Total price 393 366 kr
Sqm. price 2313 kr
Cubic m. price 789kr

Comments
All prices increase exponentially with respect to Lb but linearly with respect to h.
If the average height from floor to floor is greater than 3 meters, 2 floors are cheaper than 3.
An average increase in height of 1 dm (decimeter) on all floors costs 4200 SEK. This is a linear relationship.



Cold vs Hot Roofs
Two upper floors have been designed with prices and dimensions for all materials. Both have roofs that are 7.5 meters wide. Then, the price, price per square meter, and price per cubic meter have been calculated. These calculations depend, of course, on the choice of insulation thickness, surface materials, etc., but they provide an inductive conclusion as to whether it is more economical to warm or cold roofs.

The calculations show that the cold roof is far superior economically.

Warm Roof
(45-degree roof pitch, the wall starts where the interior ceiling height is 1.5 meters)
Price: 10 994 kr
Area: 2 sqm.
Price/sqm.: 5 497 kr/sqm.
Volume: 4.3 cubic m.
Price/cubic m.: 2 557 kr/cubic m.

Cold Roof
(The roof is drawn with a full floor underneath. This is to compare having a 1,5 and 2 floors house)

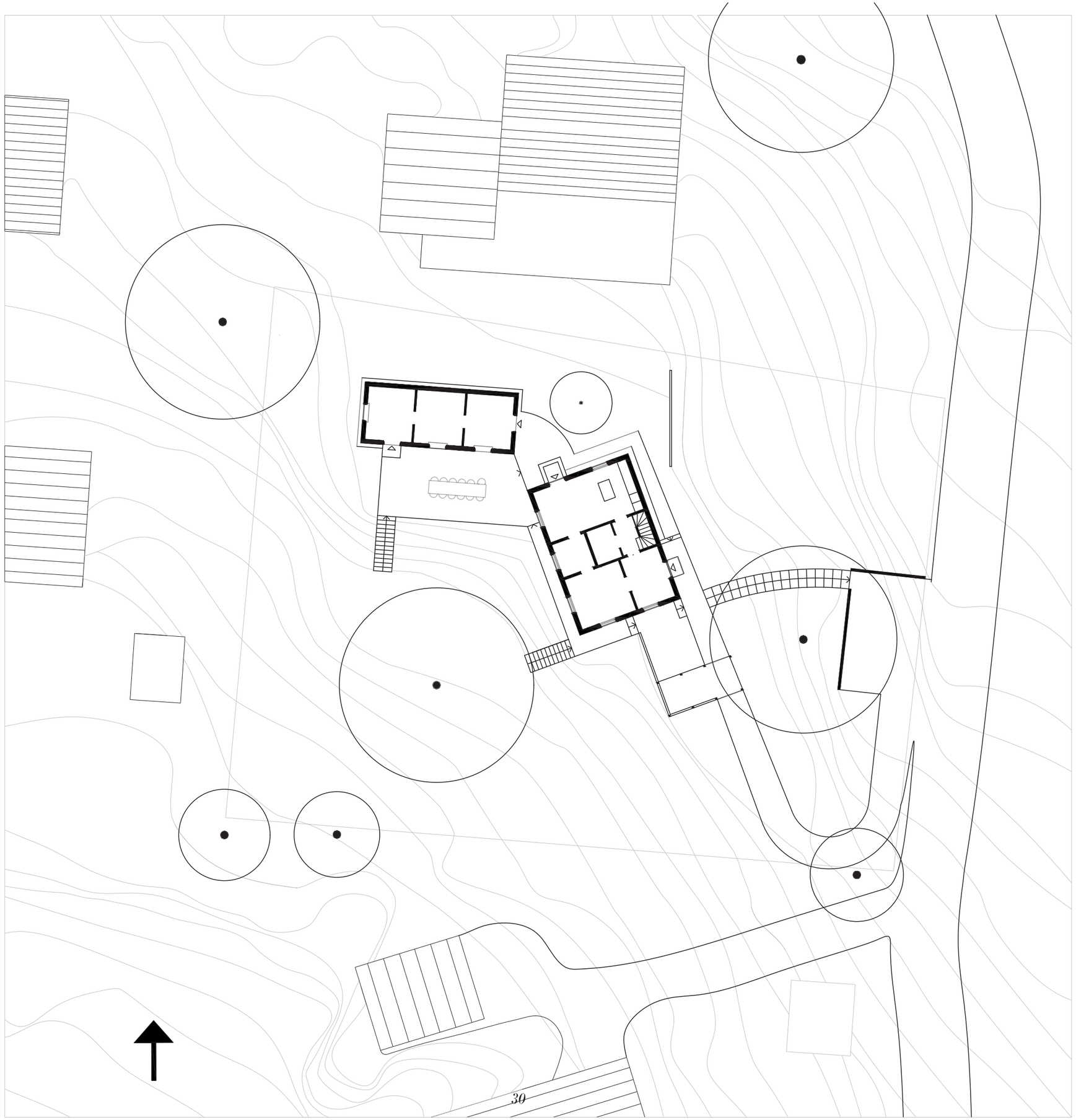
Price: 11, 92 kr
Area: 3.4 sqm.
Price/sqm: 3 409 kr/sqm.
Volume: 8.3 cubic m.
Price/m^3: 1 397 kr/sqm.

Comments:
This shows that a habitable roof is much more expensive per square meter than a non-habitable roof. Additionally, the habitable roof has poorer insulation values.

Also, the room in the habitable roof has slanted walls. Therefore, the relationship between the price per square meter and cubic meter differs.

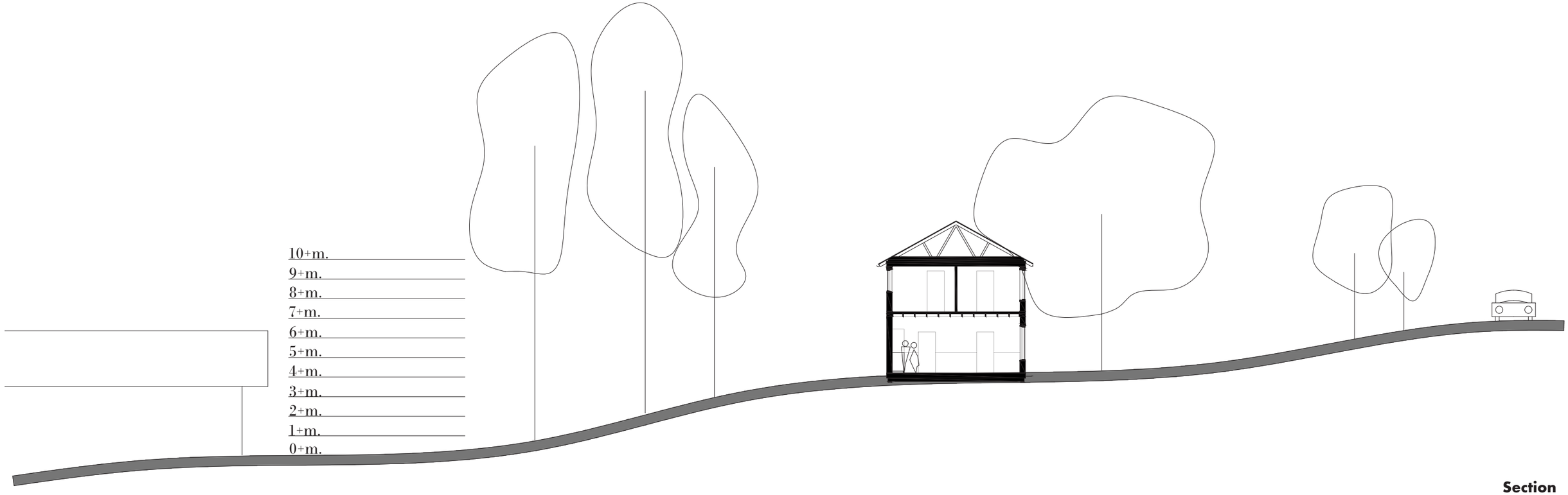
I believe it is also more labor-intensive to build a warm roof than a cold roof.

Design Proposal



Site Plan
1:250

Plot Boundary



Section Through Plot

Scale 1:200

Program
The program is general and not necessarily adapted to the specifics of the plot. The plot's characteristics and the sketching process will alter the program radically, but this serves as a starting point for what I consider a good layout of functions for a family home. The program is based on the typical life of a Swedish family and does not include any special requirements for a specific family. The program can be seen as an abstract minimum, with functions and rooms that can be added to expand the house.

Car park
Due to the dependency on cars, the parking area is an important aspect of this project. It serves as the entrance to the property, and the car is often one of the family's most valuable possessions. Therefore, it makes sense to have the parking space within the property. Garages are mostly used for utility and storage, which is important but might not be best fit in the garage typology.

Garage
In my experience, the garage is rarely used to store the car. Instead, it is usually repurposed as a workshop, garden shed, or storage space. However, the garage often plays a crucial role in shaping movement over and around the property. The garages scale should complement the main buildings.

Public Garden
The garden from the road to the house entrance takes on a public character. This is where guests walk before making their presence known.

Entrance
The space in front of the front door needs to be cared for so that the contrast between the outside and inside is not uncomfortable. The area where one might converse with someone at the door should be designed thoughtfully.

Hall
The first room in the house is the initial space. It should be spacious enough to receive guests. From this room, visitors should understand how to move toward the public areas of the house and the private should be somewhat tucked away. The room must be large enough for two families to meet and take farewell.

Second Hall
A room that seperates the entrance to the bathroom and cleaning storage underneath the staircase from the public areas of the house.

Kitchen
The kitchen must be functional and beautiful, with space for socializing around cooking. Since guests and hosts in today's dinner culture often socialize during cooking, the kitchen must be open to the dining area, but the dishes must be arranged in a way that they do not disturb during dinner. The dining area must be large enough to accommodate at least two families eating together.

Living Room
The living room should be the most pleasant space in the house, where the family's most cherished belongings are found, the family's identity is expressed, and where good evenings conclude. This room and the dining room should be the airiest and biggest rooms in the house. .

Third Room
A room that separates the energy of the kitchen from the calm of the living room, which can be used for various functions. Here, a home office can be set up, a library, or perhaps a sewing room. I believe that every house should have at least one room with an undefined function. The third room.

Private Garden
The part of the garden adjacent to the public areas of the house serves a different function than the public garden. Therefore, these areas require different designs, and it is beneficial to separate the two. The private garden is where the family sunbathes, socializes, and grills on summer evenings.

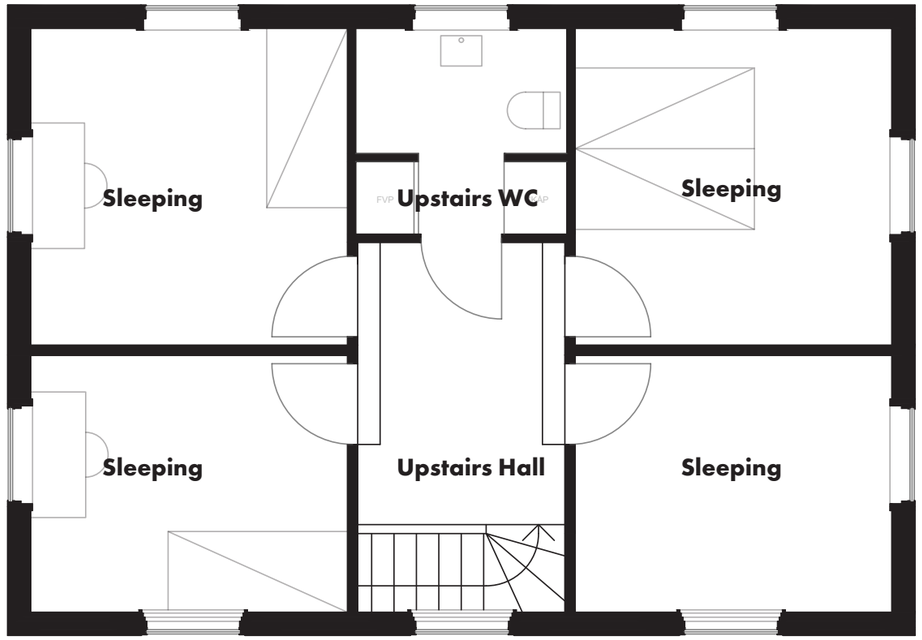
WC
The ground floor toilet is public. It should be tucked away but always close by. Its location in relation to other rooms should allow for discreet access, so that no one can be certain that you went there specifically.

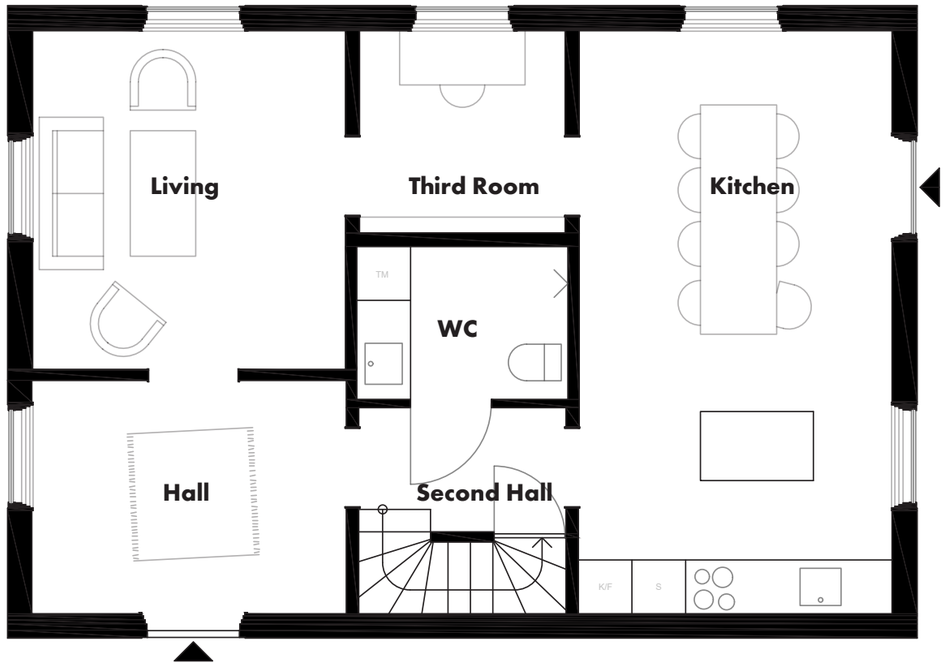
Staircase
The staircase is the strongest separating element in a two-story house. It divides the bedrooms from the public downstairs area. The staircase is split into two parts and it penetrates the wall, not the cieling. This makes the staircase as an seperating element even stronger.

Upstairs Hallway
The upstairs hallway is the least formal common area in the house. It is located in the private part of the house but is public enough to be used as a play area for children.

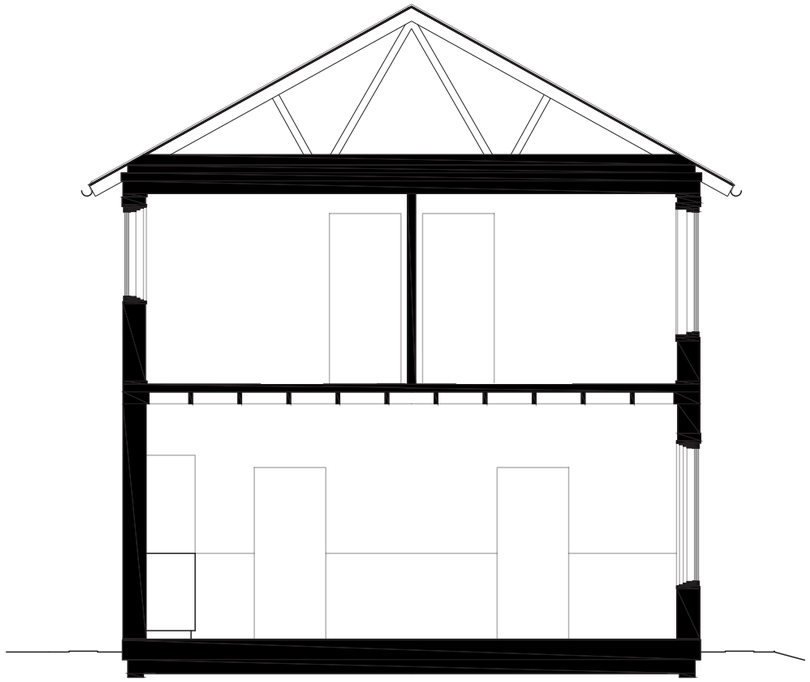
Upstairs WC
The upstairs toilet is where the family brushes their teeth and gets ready for the day. Therefore the placement of the washbasin is of extra importance.

Sleeping rooms
The sleeping rooms are simple and thus flexible and could have different uses. All sleeping rooms are big and well lit. Children's rooms are conciously big because this is where the child plays and expresses themselves throughout their upbringing. There should be enough space for studying, play, and hobbies.

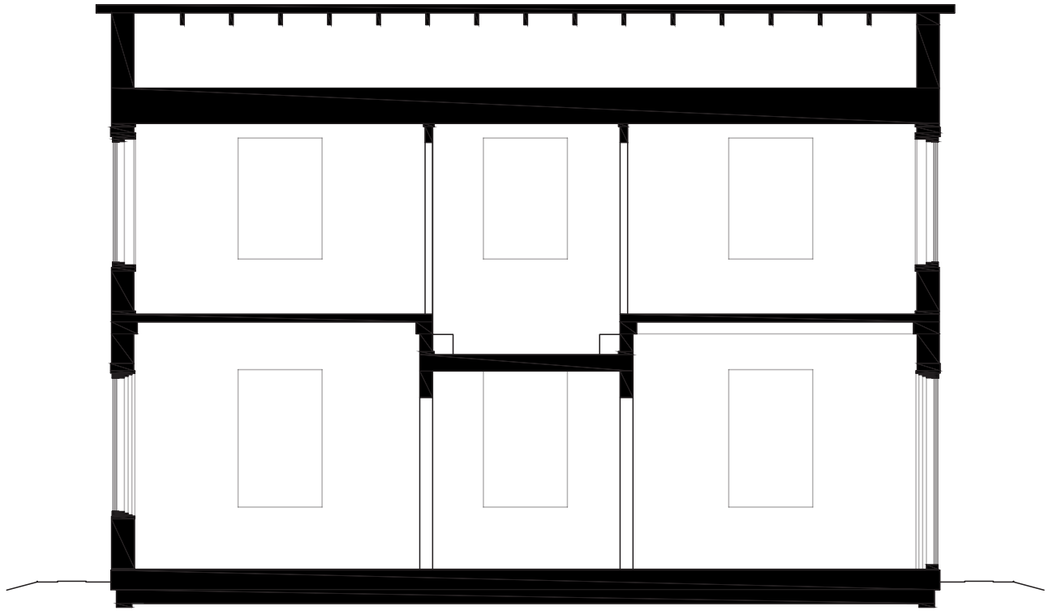




Plans 1:75

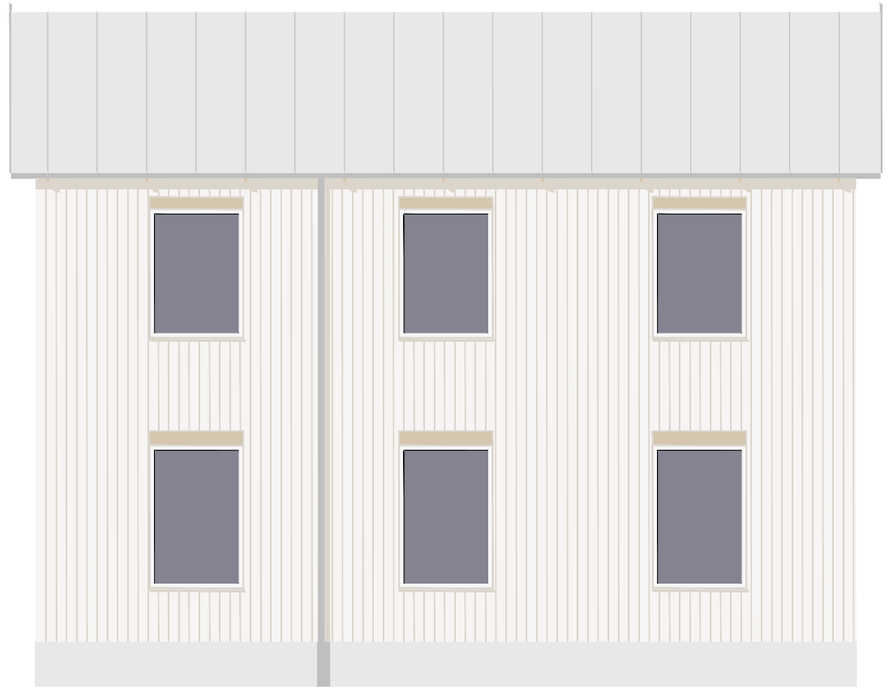


Section
Short 1:75

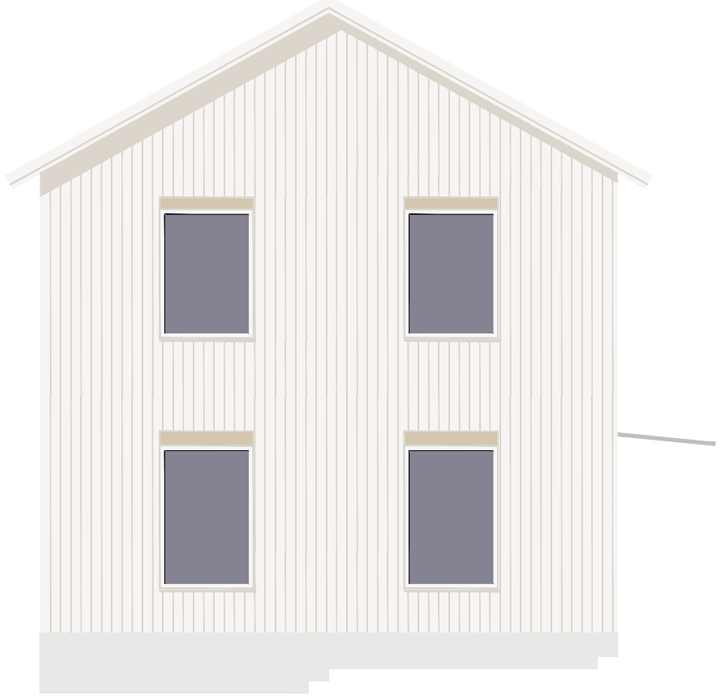


Section
Long 1:75

Facade North



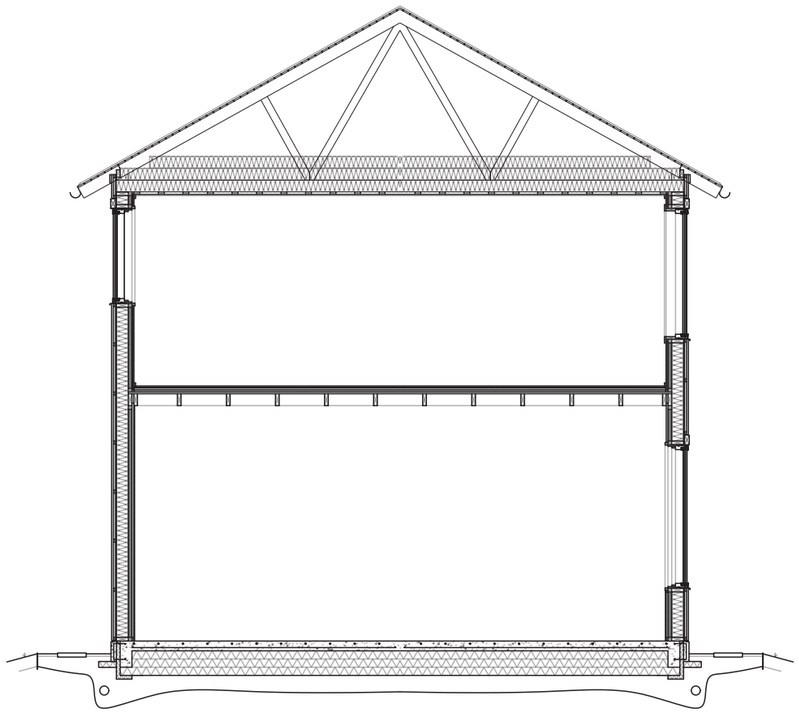
Facade West



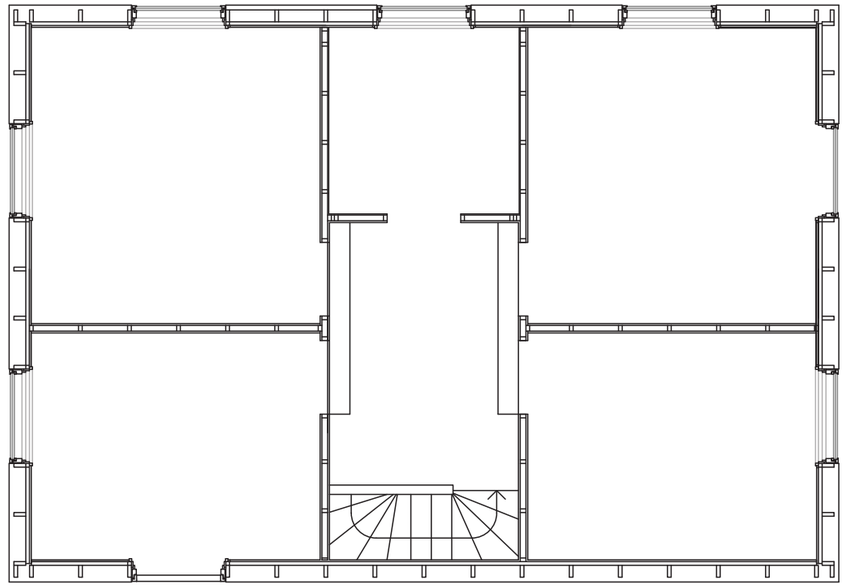
Facade South

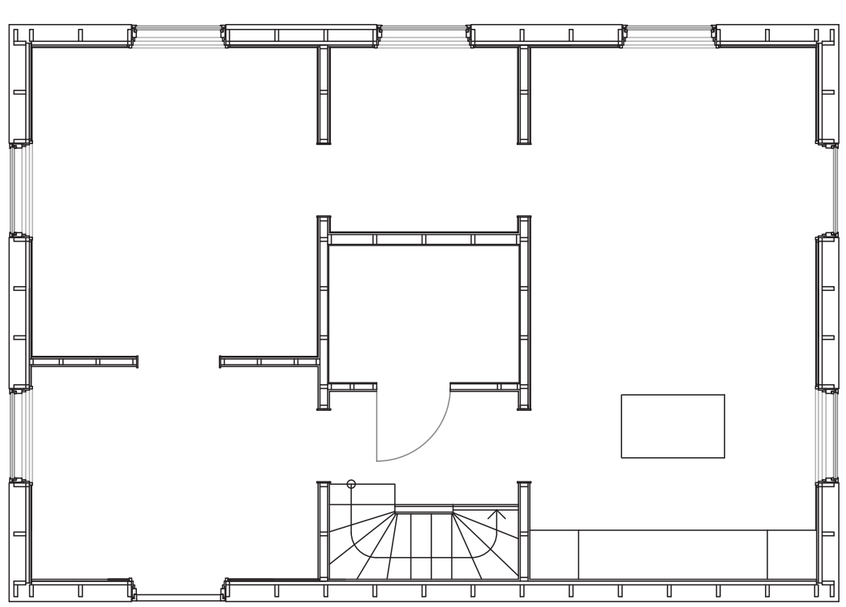
Facade East

Scale
1:75

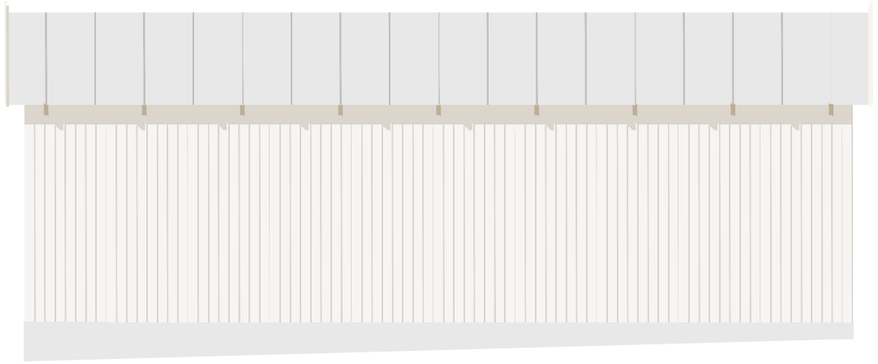


Section With Details
1:75

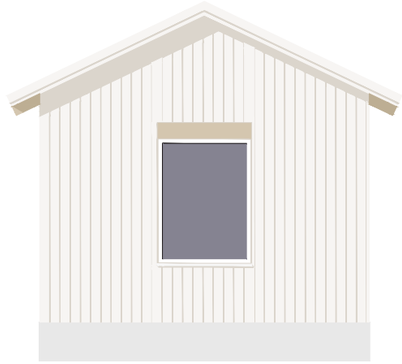




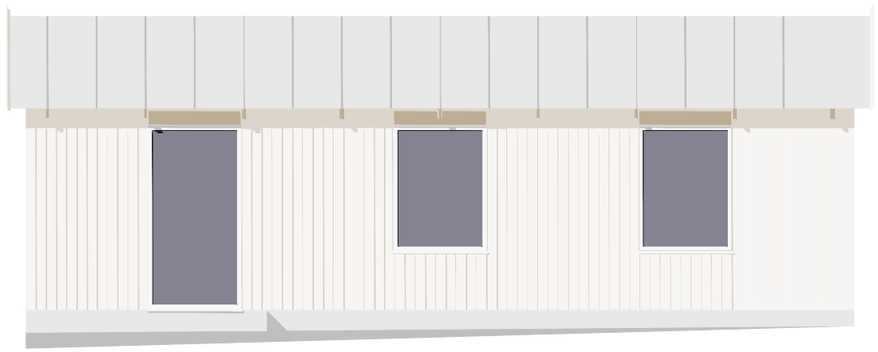
Plan With Details
1:75
The Studs all align with the openings and roof joists: no additional work or material is used to accomodate openings.



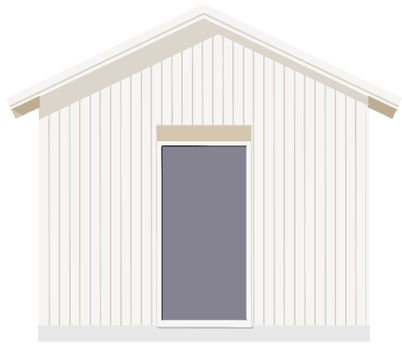
Facade North Attefall-House



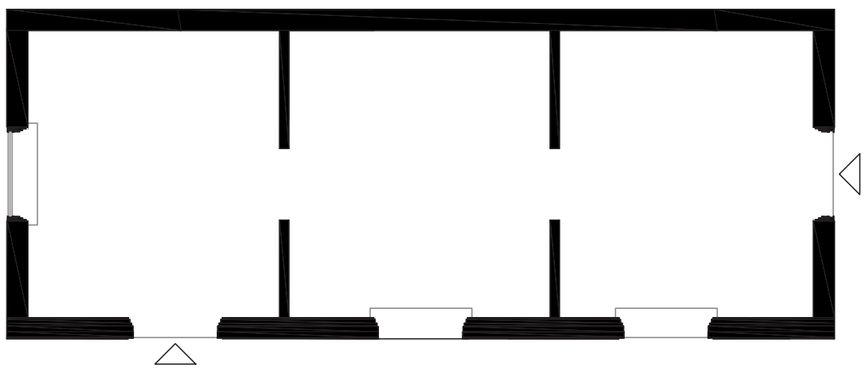
Facade West Attefall-House



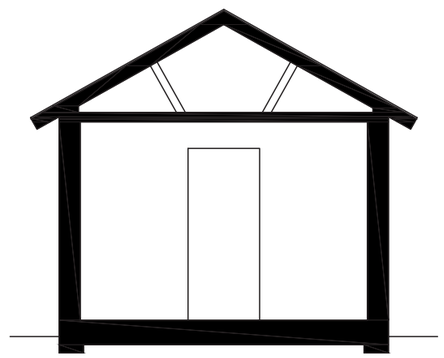
Facade South Attefall-House



Facade East Attefall-House

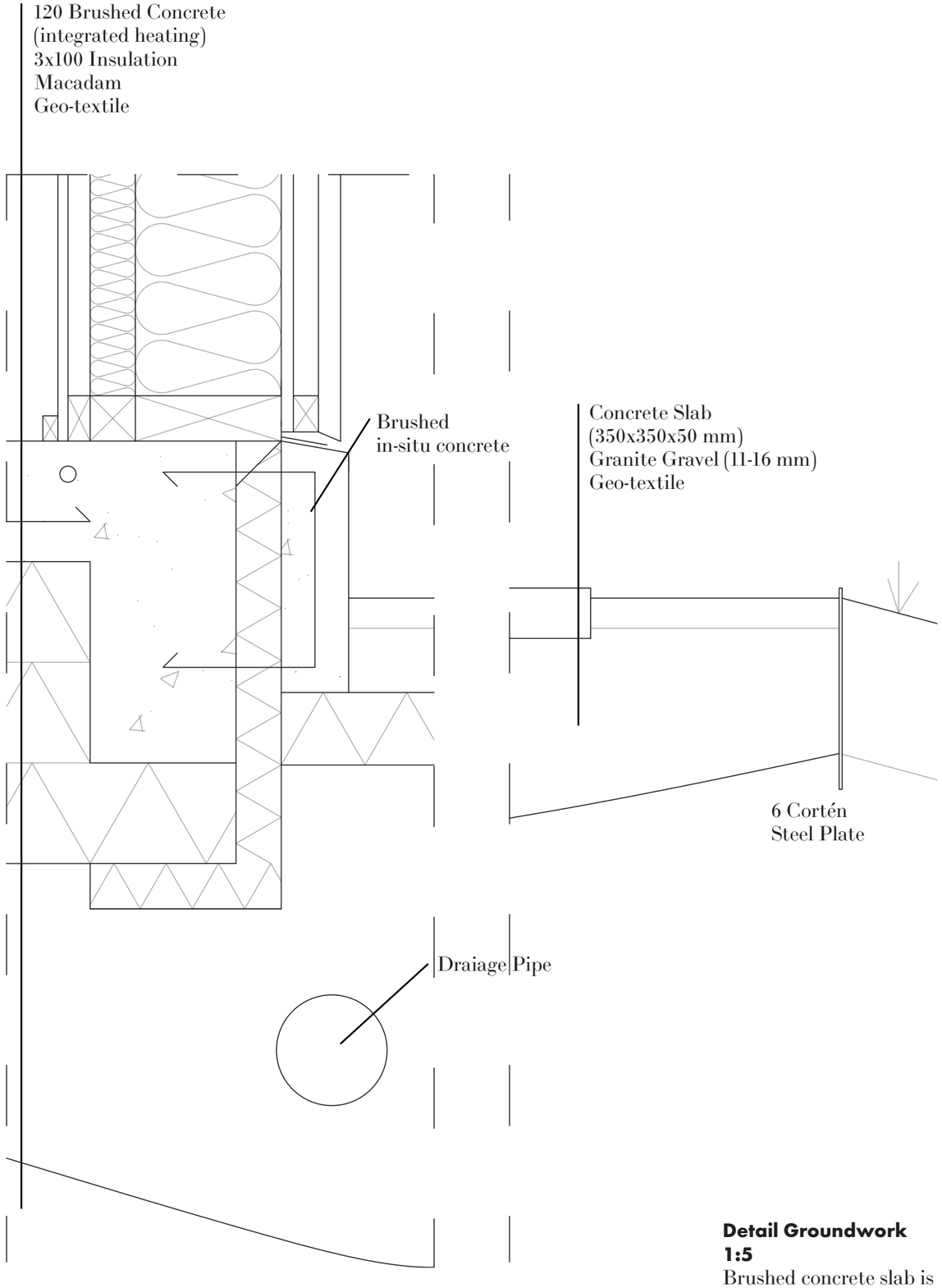


Plan Attefall-House

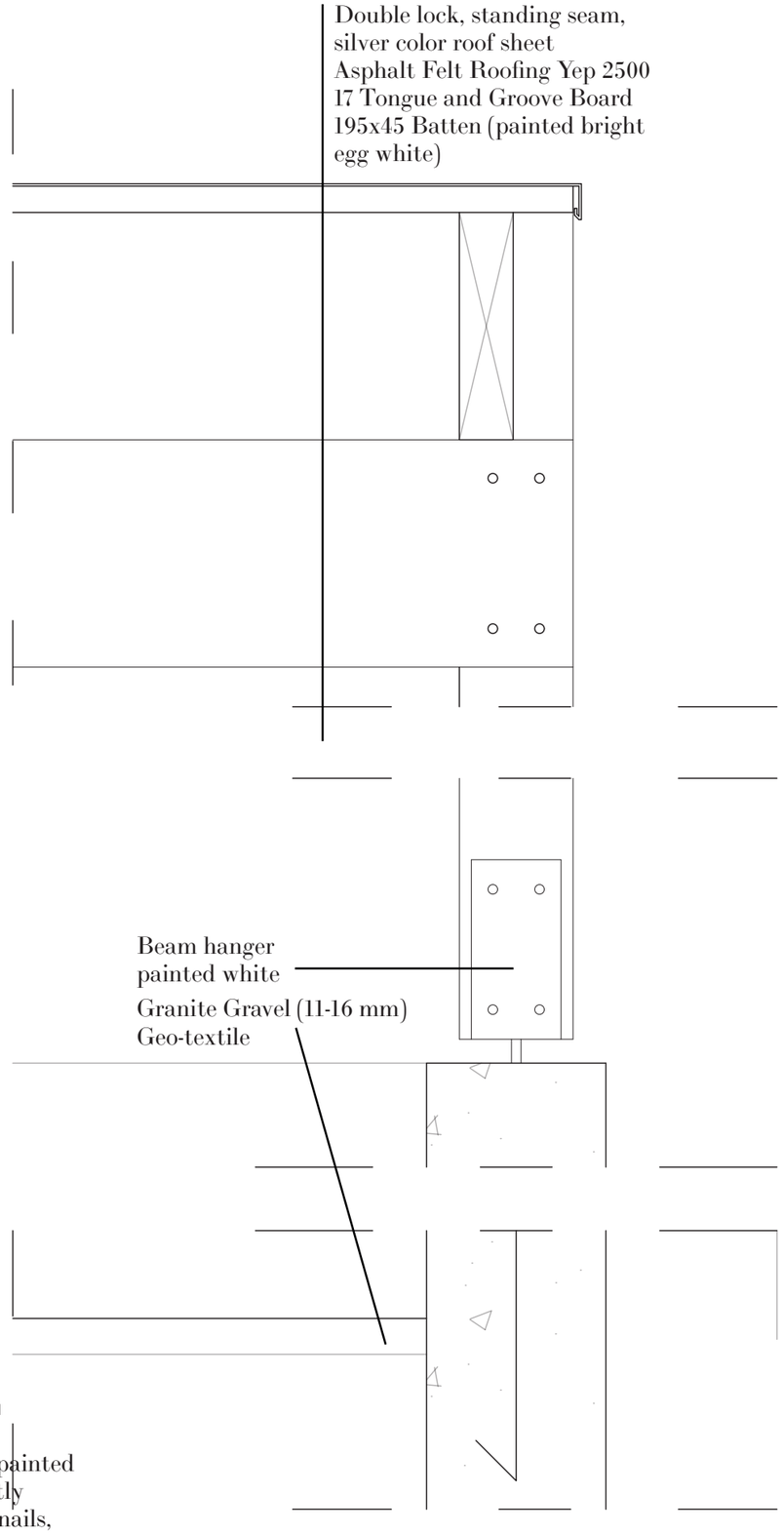


Section Attefall-House

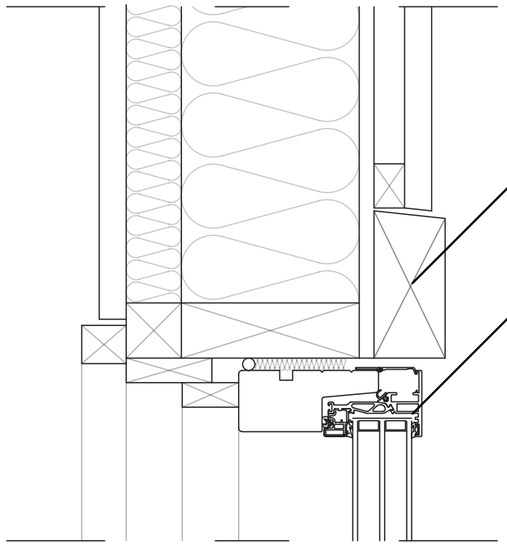
Scale 1:75

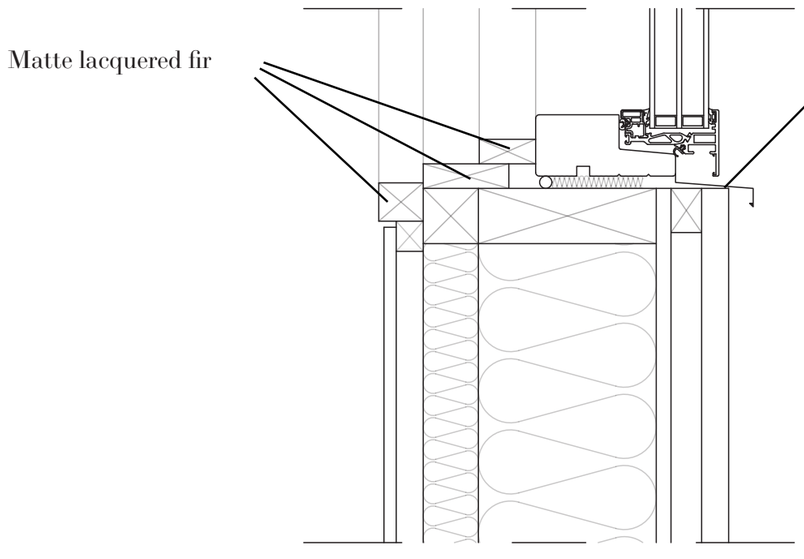


Detail Groundwork
1:5
Brushed concrete slab is cast around the concrete slab to accentuate the concrete foundation. The house stands firmly ontop of the foundation.

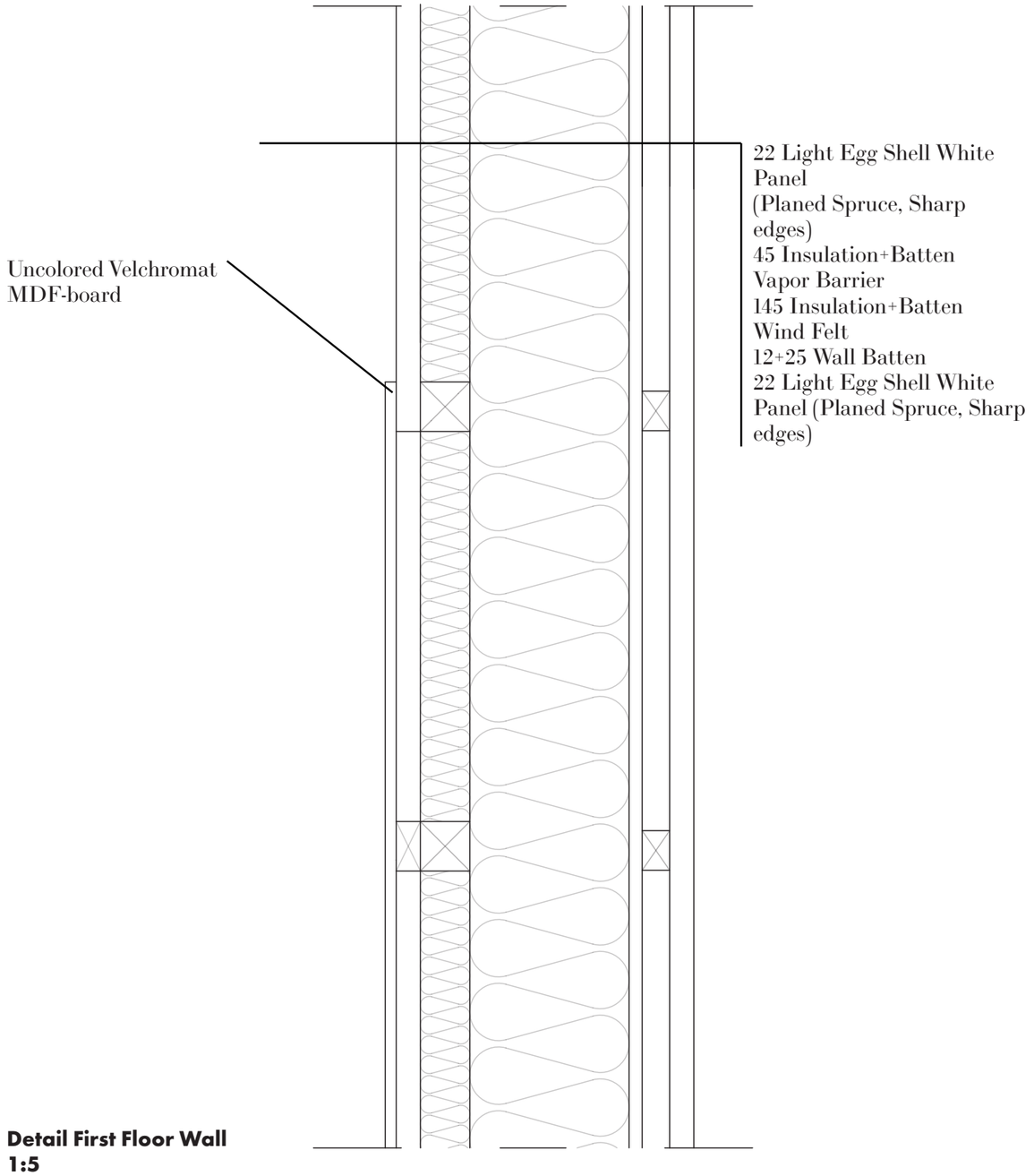


Detail Pergola
1:5
The Pergola is painted white and strictly techtonic. The nails, beam hangers and connections are shown but also painted white.

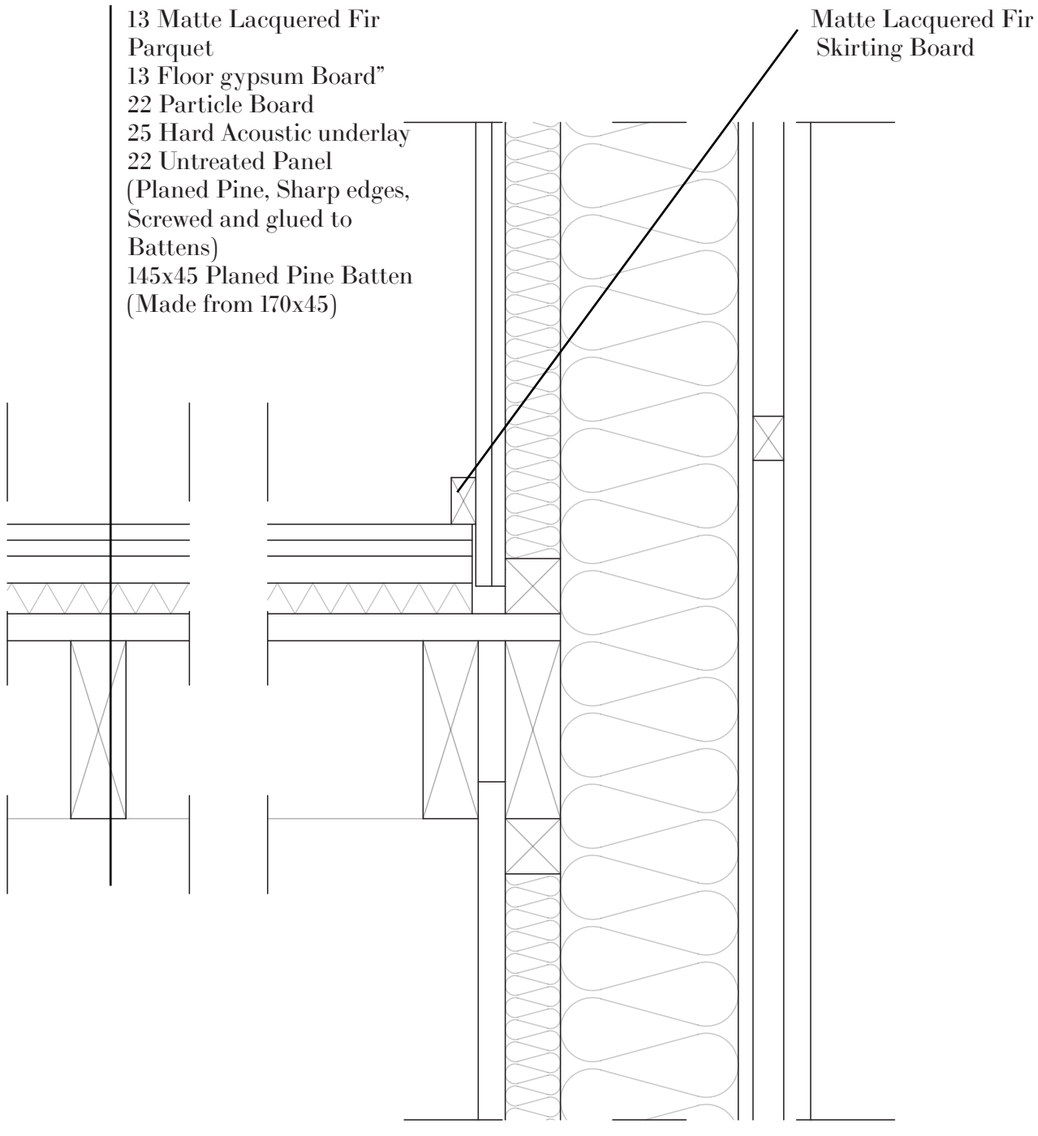




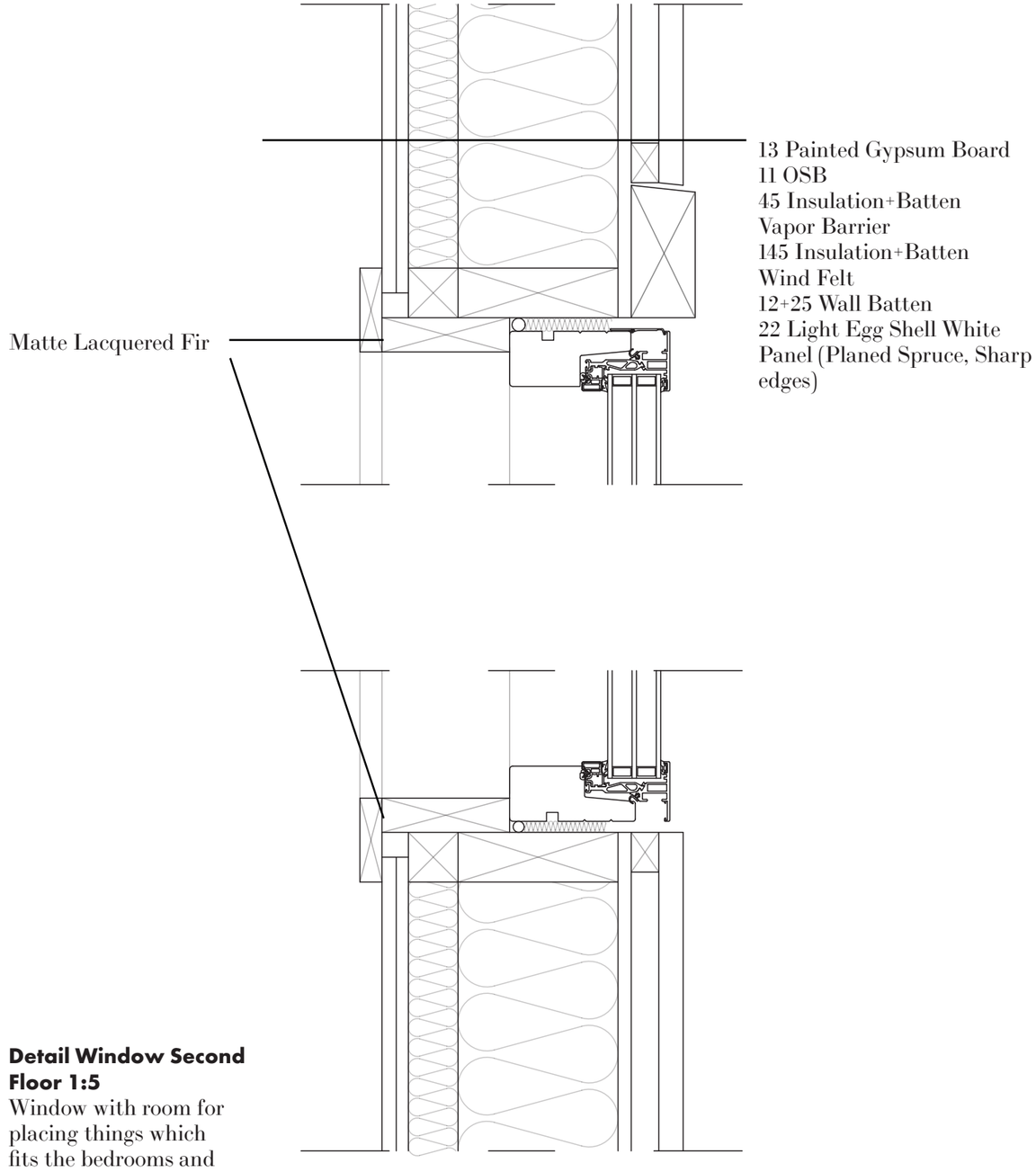
Detail First Floor Window 1:5
Window on first floor is designed as simple as possible while also accentuating the sunlight and thinness of the wall by having a relief around the window. This window detail is also used on the three eastward windows on the second floor.



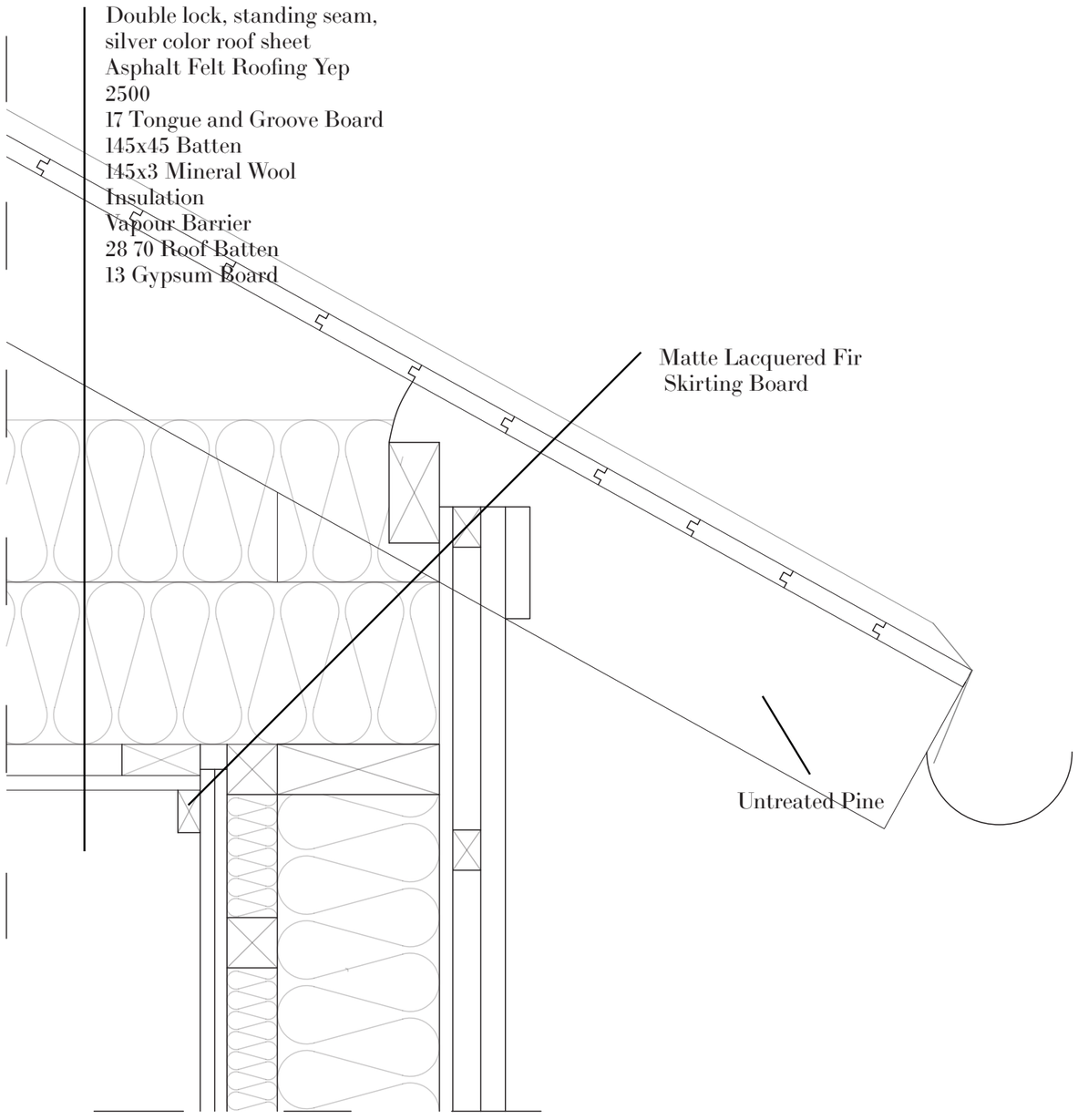
Detail First Floor Wall 1:5
The wall is painted with the same color outside and in. the lower part of the inner wall is covered with uncolored Velchromat board to give warmth and a sense of luxury.



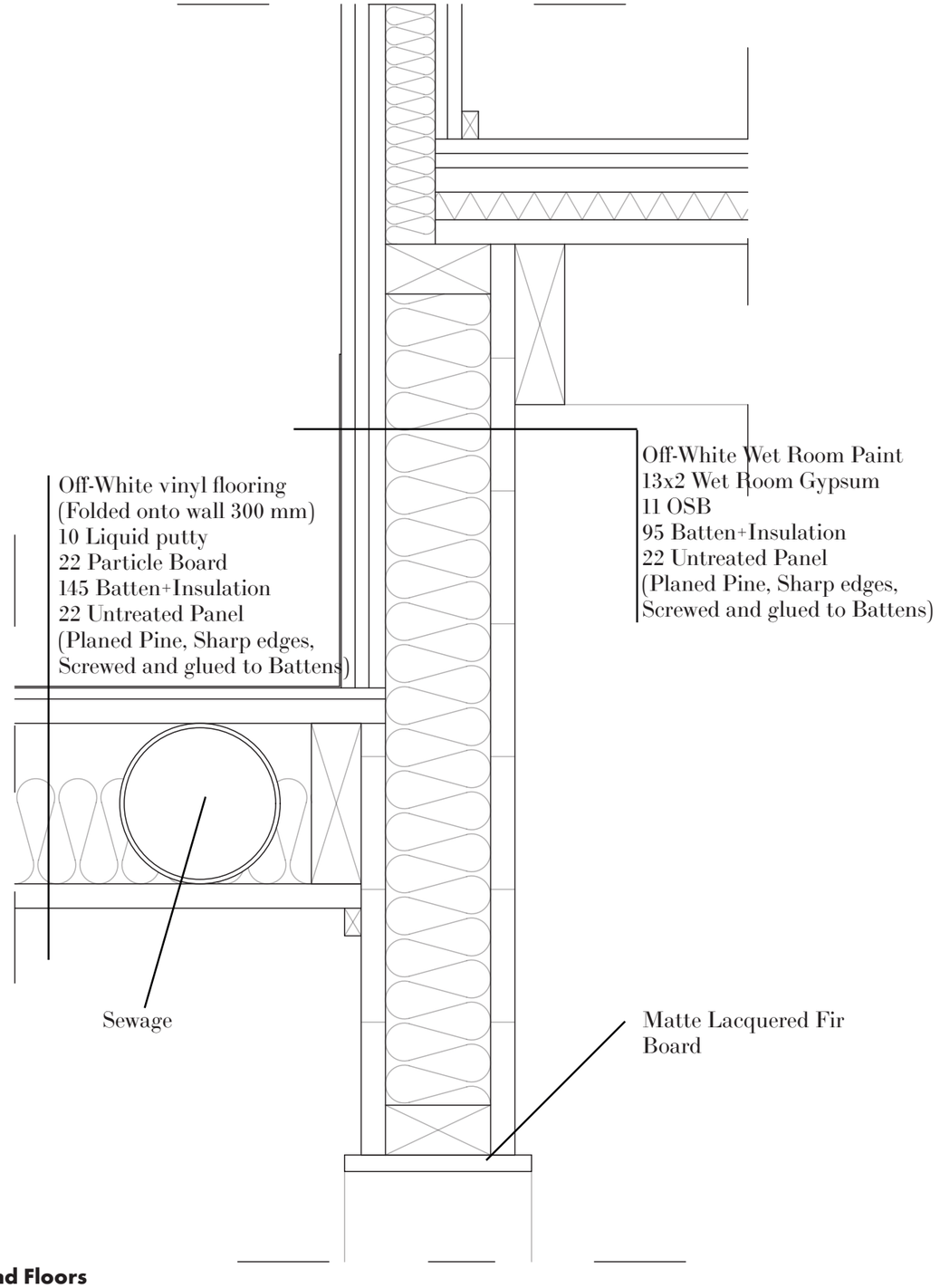
Detail Floor Structure Kitchen and Living 1:5
The interior roof in the Kitchen and Living room has a visible structure. This is the most luxurious part of the house.



Detail Window Second Floor 1:5
Window with room for placing things which fits the bedrooms and the upstairs toilet. Is designed like a frame around the view.
The wall is clad with gypsum board. I believe kids want to paint and choose their own wallpaper.



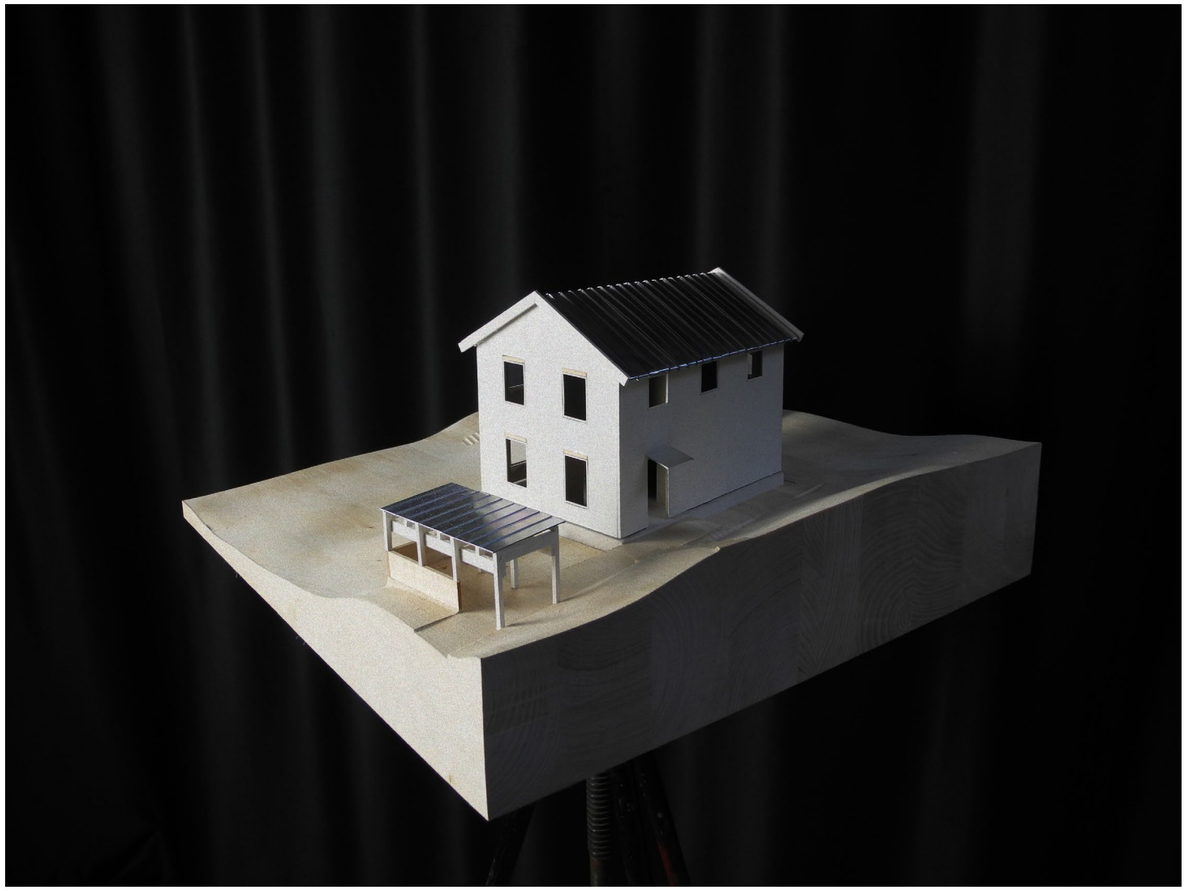
Detail Roof
1:5
The roof is of steel plate and all technical pipes exit the building from just below the roof. No perforations in the roof sheeting is made.

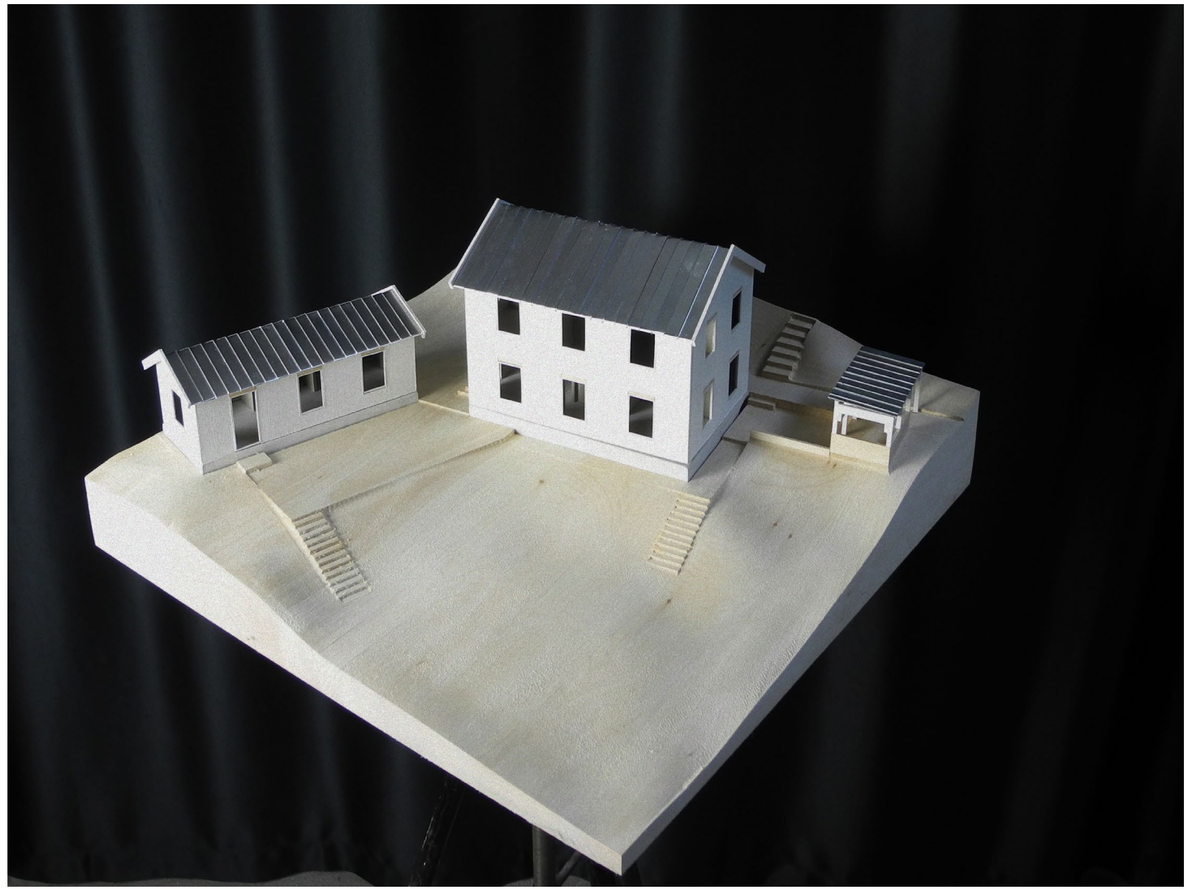


Detail Walls and Floors
Toilet-Bedroom
Third Room and Living
Room
1:5

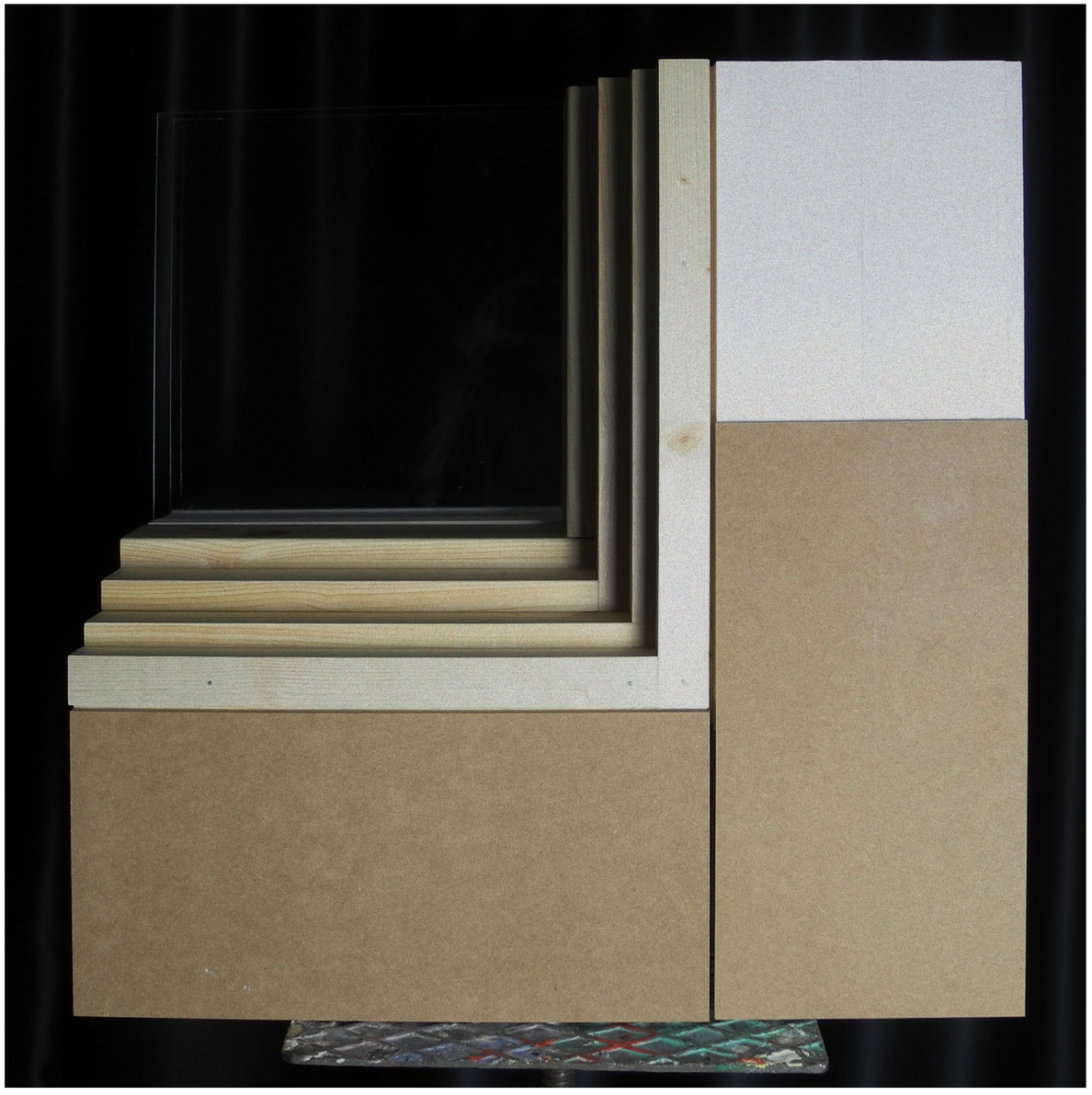
Perspective of Kitchen

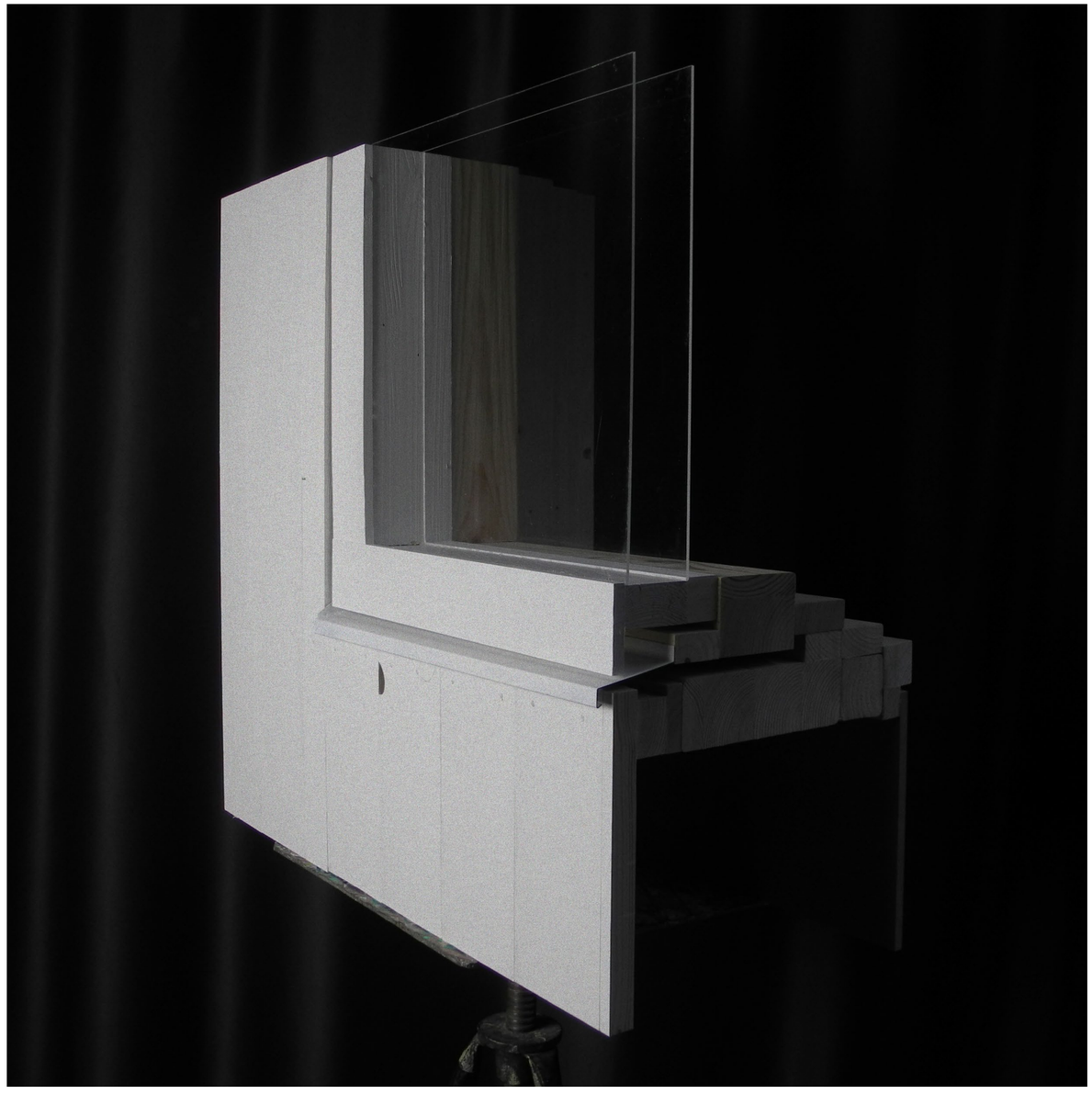
Perspective of Living Room Window





Photographs of Site Model





Photographs of 1 to 1
Window Detail Model

Photograph of 1 to 10
Structure Model

The main question this thesis explored was how a high-quality single-family house could be built cost-efficiently. This question was examined from three main perspectives, which were later merged and processed into a project proposal presented in the thesis. These perspectives were mathematical calculation, continuous comparison and architectural references.

The first approach involved creating mathematical models to understand how the house's form and construction choices influenced its cost. This work turned out to be much larger in scope than what is visible in the booklet. This was partly because the majority of the results were either trivially obvious or so ambiguous that they became difficult to show.

When the work on these mathematical models began, large Swedish construction companies were contacted to understand how they calculated the actual cost of parts of a house. For these companies, this is a critical part of their business operations and has been meticulously developed, both to estimate expenses and to minimize downtime. These price lists cannot be presented here as they are business secrets. From what I understood, their pricing models were based on three parameters: first, how long it takes for a worker to perform a certain task (e.g., installing one square meter of plasterboard), multiplied by the cost of labor; second, the current price of one square meter of plasterboard; and third, internal estimates of time based on company experience and industry standards, which regulate how time should be calculated. Even if a task actually takes 10 minutes, they had to account for more time to accommodate slower workers. This meant that faster workers were not rewarded in the company's cost estimates and that these calculations in reality are not accurate by nature.

This type of calculation model was interesting, even though it had some drawbacks that led me to choose an alternative method of calculation.

Firstly, I did not have access to data on how long different work tasks take, and secondly, pursuing that kind of precision would have been beside the point of this thesis. What I tried to do instead was to make each square meter of wall easier to construct; a wall, as I had designed it in this project, was not the same as a generic Swedish wall that the standard calculation model would assume.

As a consequence, both my model and the design of the house were based on the materials that were purchased. One underlying assumption was that the more a material needs to be processed, the more expensive it becomes. Therefore, I focused not on labor time and material cost per square meter, but rather on material price, quantity, and the level of required refinement. So the core question shifted from "How can we build the cheapest wall per- square meter as quickly as possible?" to: "How can we use as little material as possible, requiring as little processing as possible?"

The drawback of my calculation model was that it could not produce a final price that a contractor or builder could use to evaluate their investment. But the advantage, aligned with the thesis question, was that it yielded a working model that viewed the building's components from a broader perspective and made the design process more holistically manageable. I cannot say for certain, but I was convinced that this approach better contributed to lowering the final cost of the house, while the construction companies' model was better suited for investment forecasting.

Based on this main model, other calculations emerged. Four of these, which provided concrete metrics and tangible results, were presented earlier. Something I wanted to highlight in this discussion is that these calculations, and, in fact, all calculations, were interdependent. For example, the wall thickness was first determined based on the cost of walls versus heating costs, and then the cost of a heated roof versus an unheated roof was based on the most optimal wall thickness. This eventually created a network of interdependent relationships between different calculations, so integrated that one must be cautious about drawing general conclusions regarding what is cost-efficient.

To summarize this reflection, I wanted to emphasize that the project began with an openness toward what kind of house these calculations might lead to. Over time, it turned out to be a house that look like a house that llok like a house. This was amusing, and towards the end of the design process, I decided to lean into that aspect more and more.

The second perspective simply involved comparing different choices pragmatically. A great deal of time was spent comparing prices of various materials: how much more expensive are Schüco windows compared to Velfac? Is it worth the difference in terms of heating costs, purchase price, and architectural impact? Such questions formed a major part of the project process and were embedded in the final product. The project's concluding stance on the question "Is it worth it?" was to cut costs wherever possible in order to afford more expensive materials and care where it truly made a difference. For example, the ceiling on the ground floor and the added cast around the foundation were probably expensive and purely aesthetic but were intended to elevate the house from merely cheap to worth its price.

The third perspective involved actively using built references as support. The design process was long, and an immense number of buildings, places, and detail solutions were studied to find examples and- inspiration for this small house. Four buildings that I referenced at the end of the process were presented in the booklet. What they had in common was their modesty and restraint with architectural elements, which in turn gave them character. That attitude was applied in this project. The house was very simple, and its distinctive features lay in the placement of the windows at the outermost edge of the walls, the roof above the front door, and the pine decorations above the windows.

Ultimately, these three methods were used by me as a designer to compose a single-family house that aimed to answer the project's central question:

How can a high-quality, cost-efficient, light-frame construction house be built by basing the design on maximizing the potential of materials and labor?

Whether or not the project successfully answered this question is for the reader to decide; I did not present a final cost for the house, so direct comparisons with existing buildings is impossible. Instead, my answer lay not in showing a house and comparing it to others, but in presenting a qualitative building based on the simplest construction methods and a series of cost-versus-quality decisions in each individual design instance.

Basing the design on a the building system and the dimensions of individual elements is not only a way to save money. It gives an architectural order. A system of proportions, a sense of honesty, and a reason for decoration. An architectural order that, since the advent of modernism, has always been questioned due to its arbitrariness and its historical backwardness. But here, I will present an architectural order that is directly born from our time. An order that manifests our time.

A question every house answers, which is central to the studio in which this thesis is being done, is: How does the building's expression relate to its construction? The answer that this project provides is: not boastful exhibitionism, but sincerity. There are no gestures that make the building flaunt its construction. There are no prude gestures to conceal its construction. There is no attempt to tell a story about a construction that doesn't exist. This project is a revival of the original temple, before it was rebuilt in stone and became a symbol. This house is not an icon or a symbol. This house is a house.

Reference Litterature

Kungliga Bostadsstyrelsens skrifter (1953)

Regelhuset: *Ett Ekonomiskt Handbyggt Trähus*

Svenskt trä (2020) *Att välja trä: En faktasklift*

APA- The Engineered Wood Association (2016)
Advanced Framing: Construction Guide

https://www.vattenfall.se/elavtal/elpriser/rorligt-elpris/prishistorik/ (2025-03-10)

https://www.bygghemma.se/reportage-och-guider/guide-for-bergvarme-kostnad-pris-och-besparingar/ (2025-03-10)

Reference Images

1-2 Kungliga Bostadsstyrelsens skrifter (1953)

Regelhuset: *Ett Ekonomiskt Handbyggt Trähus*

3-5 Träguieden.se

6-7 APA- The Engineered Wood Association (2016)

8-9 celsing.se

10-11 digitaltarkiv.se

12-13 orthoslogos.fr

All remaining images used in this booklet has been produced or photographed by me.

OBS

Chat-GPT 4 has been used in helping me translating swedish text into english and used to grammar, and spell-check text. It has not been used to generate text.