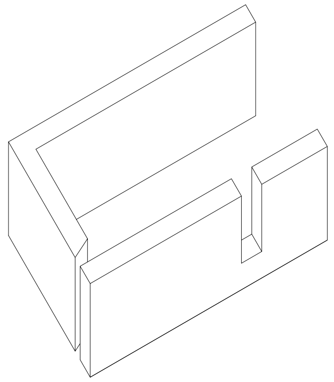
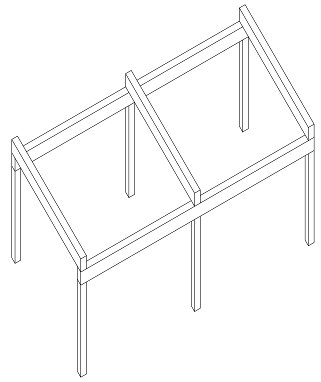
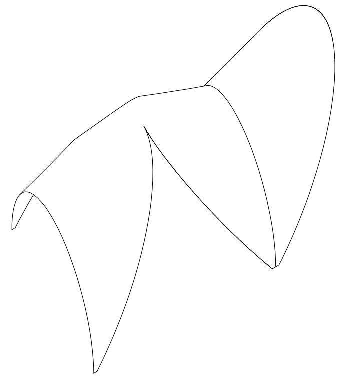
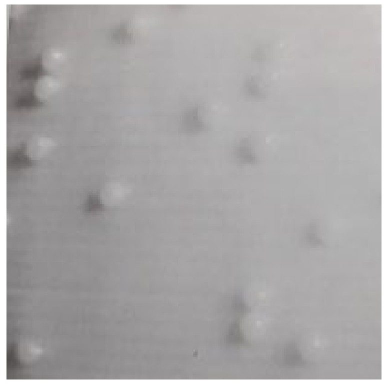
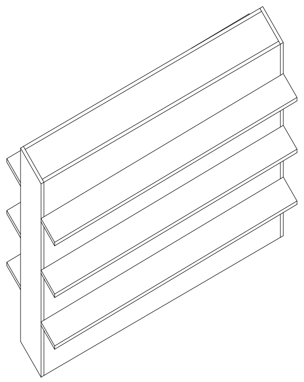
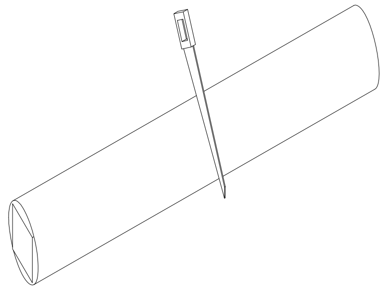
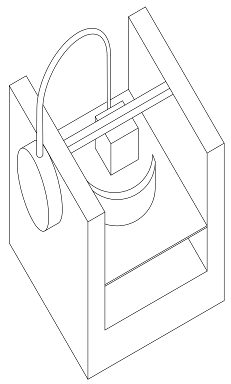
THE ESSENCE OF A MATERIAL?

An Investigation of Rammed Earth, Wood and Plastic

A Thesis by Anna Willemark

Chalmers School of Architecture – Department of Architecture and Civil Engineering

Exeminer: Jonas Lundberg

Tutors: Daniel Norell, Karin Hedlund

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An Investigation of Rammed Earth, Wood and Plastic

Anna Willemark

Architecture and Urban Design

Graduation spring 2017

CHALMERS

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Abstract

The essence of materials and whether this exists or not, has been discussed by architects throughout history. Frank Lloyd Wright claimed that the material determined the shape of the building and Louis Kahn thought the arch is the structural essence of a brick. Today, the question of materials' nature is more complicated than ever. With new technology and fabrication methods, materials can be manipulated and get completely new properties. How does this affect the essence of the materials? Do materials even have one today?

This thesis is an investigation of what can be considered the essence of materials today, combined with specific fabrication processes and structural principles. These parameters can be regarded so closely intersected that today, they are dependent on each other.

Three versions of the same small cabin, with similar predetermined features, are used for investigations, where qualities and performative properties of the materials are compared. Each version has different materials, tectonics and fabrication methods: rammed earth is form-active, fabricated with molds, wood vector-active, with only sticks used and plastic surface-active and 3d-printed.

The investigations are mainly in physical model, iterating between different scales. The purpose of this investigation is to discover whether materials have an essence and how it is made visible. This is illustrated by the three versions with separate materials and one final hybrid version with all three materials combined in one design, showing how the materials do have their own essence, but allowing them to be true to their nature does not necessarily lead to an expected outcome.

Figure 1. Vector-active , Shisen-do (Muravej, 2012)

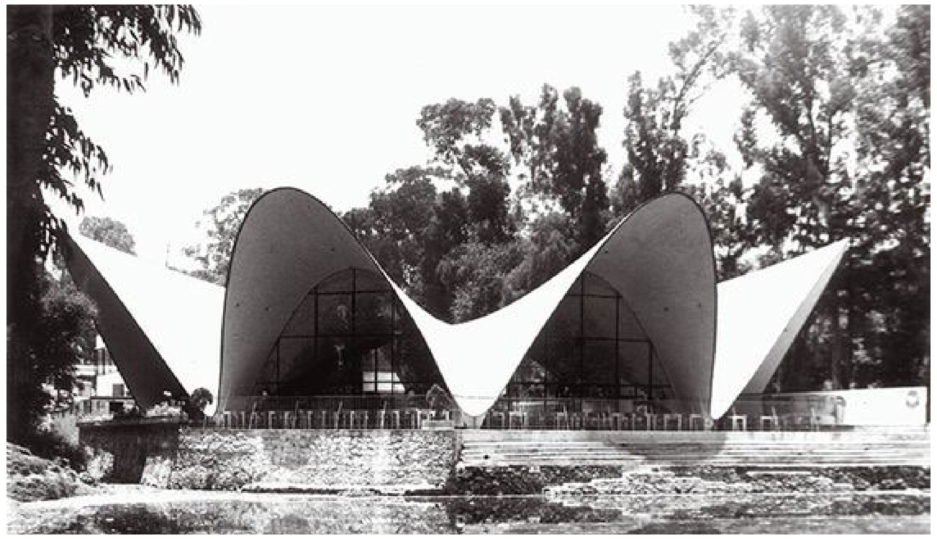


Figure 2. Surface-active, Candela. Los Manantiales (RIBA, 1958)

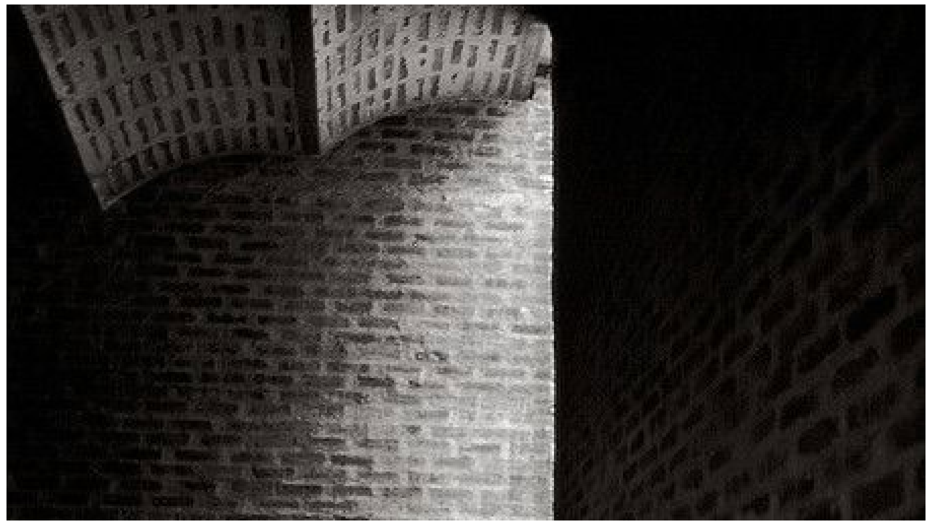


Figure 3. Form-active, Lewerenz. St Mark's Church (Torra, 2009)

Student Background

Bsc Architecture – Chalmers University of Technology

Master's Program: Architecture and Urban Design

Material and Detail
Academic Writing
Wood, Tree, Building (The Oslo School of Architecture and Design)
Practical Concepts (The Oslo School of Architecture and Design)
Complex Building (The Oslo School of Architecture and Design)

Name: Anna Willemark
E-mail: annachristinawillemark@gmail.com
Phone: 0706124664

Aim

The purpose of this investigation is to bring new perspectives to the essence of materials and architecture as well as the materials of the investigation. This is often brought up as a quality, why it is important to question what that means and why we view it as a quality. It is also important to explore how the goal of essence affects the architecture and how it is linked to materiality. Buildings considered to have an honest nature always seems to have an intimate connection to its material, as in the buildings of Louis Kahn and Peter Zumthor.

A building's elements is its materials and therefore honesty will always be linked with materiality. The materials are creating spaces with different structural methods, suitable for the material, and therefore the tectonic aspect of the material is of extra focus.

Today, with new digital processes and tools, materials and manipulation, the word essence is a complicated word. This thesis investigates materiality and how to use the materials as a tool when designing, while discussing what this means today. To narrow the perspective, the materials used in this thesis have different fabrication methods and structural properties; the wooden project is combined with baloon framing – tectonic, the rammed earth with mass – stereotomy – and molds, and the plastic with a surface-active structure and 3D printing.

This way, both traditional materials and fabrication methods and newer ones can be investigated.

Purpose

This thesis investigates a contemporary notion of essence in materials through a design project. The method is influenced by a set of "rules", gained by a literature study, where the project is developed from these rules, the chosen material, the structural principle and the fabrication method. By designing a project which displays the material in an, what we today regard as, a way which is true to the material, where the design is completely dependent on the material and its surface and structure, this thesis is also an investigation of materiality. The three different versions of the project, each in a different material, are a comparison of essence in different materials, which are later combined into one final composite version.

The typology used for the investigation is a "Friggebod", which could be considered a modern version of Marc-Antoine Laugier's The Primitive Hut, a primitive and fundamental building. The design of the project is collected from a Friggebod from Byggmax, Peter-10. Some features are selected from this hut, that is going to be apparent in all three versions. In the end, the goal is to combine the three materials (and tectonic principles) into one project.

Background

Essence in architecture or materials is a notion architects have used for a long time, but the meaning of the word "essence" has shifted over the time epocs. In 1756, Carlo Lodoli stated that "the nature of wood is formally different from the nature of stone, so too the forms which you give wood in the construction of a building have to be different from those of stone" (Poerschke, 2013). In this time, nature in materials was viewed in the light of structural properties. In the Arts and Crafts movement, the craftmanship was regarded the most important quality of honesty, which is being questioned today by Michael Maltzan (Borden, Meredith, 2012). In the epoc of Modernism, there was a shift from viewing the craftmanship and ornament as the essential quality of honesty, to the surface of the material. The ornament was regarded unnecessary and undesirable, Adolf Loos stated that one should not celebrate the ornament but the material (Borden, Meredith, 2012). In The Principle of Cladding, Loos writes that "It is a penchant for the surface of a material. Coloring and cladding. Painting wood in any color except the one of wood is allowed" (Poerschke, 2013).

In the later era of Modernism, a new view of honesty and materials was created by architects as Louis Kahn, which is the desire to use materials in optimal ways and view the structure and surface as one. In his famous speech at the Pratt Institute in 1973, Kahn illustrated the importance of using materials in what he regarded as the correct way, by simulating a conversation with a brick: "You say to brick. 'What do you want, brick?' And brick says to you, 'I like an arch.' And you say to brick, 'Look, I want one too, but arches are expensive and I can use a concrete lintel over you, over an opening.' And then you say, 'What do you think of that, brick?' Brick says, 'I like an arch.' It's important, you see, that you honor the material that you use. [...] You can only do it if you honor the brick and glorify the brick instead of just shortchanging it or giving it an inferior job to do, where it loses its character" (Poerschke, 2013).

This is an example to how linked architecuture is to materiality. Using materials as a tool for people to understand the building, is a pedagogic way to be architecturally true to the material.

Figure 4. San Francesco della Vigna, Lodoli (Poerschke 2013)

Figure 5. Michaelerhaus, Loos (Cooper 2013)

Figure 6. The Red House (Banerjee 2009)

Figure 7. Indian Institute of Management, Kahn (Gupta 2013)

This view of materiality has remained intact to our times, where we still view essence of materials as the times when inner and outer materiality are one, as in Peter Zumthor's Swiss Pavilion. The will to combine the two main views of materials, as surface and as structural form, is an indicator of the desire of authenticity, truth and honesty. Zumthor himself states that "Architecture is always a concrete matter which can be experienced in a concrete way" (Poerschke, 2013). There are many architects who choose to concentrate on one material and its qualities (Shigeru Bahn, Kengo Kuma) and there seems to be a wish to go back to more simple ways of constructing a house, with focus on honesty, quality and sustainability, the Semrén & Månsson housing project on Danska vägen, Göteborg, with masonry walls, is an example of this.

This is probably an indication of the trends of the world at large, where biographical novels such as Min kamp by Karl Ove Knausgård and the diaries of Lars Norén win hearts of both audiences and critics, a movie like Boyhood gets top scores by critics. It is authentic and then it is automatically best, according to current criteria. The truth has never mattered as much as it does today, it would seem, and therefore the material truth of a building is a current and important question.

But at the same time, the material truth has never been as complicated as today. With new techniques, fabrication processes and composite materials, we are no longer bound to so called "natural properties" of materials, since these properties can be manipulated to almost anything (Borden, Meredith, 2012). According to Gail Peter Borden and Michael Meredith, materials then grow less important, which basically means any building could be made in any material. Borden and Meredith are in their text "Foreign Matter" discussing Kenneth Frampton's notion "Cardboard Architecture", claiming that today, words like "natural" and "traditional" are as artificial as cardboard. The materiality of architecture is no longer about materials, but matter, i.e. what materials are made of, fabrication processes and assembly (Borden, Meredith, 2012). These aspects are important to consider when discussing what essence is today and what it will be in the future.


Figure 8. Danska vägen Semrén + Månsson (Semrén + Månsson 2013)

Figure 9. Min kamp Knausgård (Goodreads 2009)

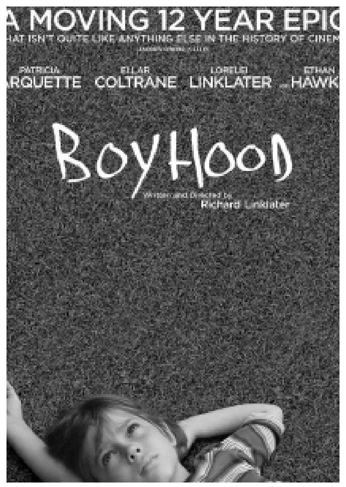


Figure 10. Boyhood (IFC Films 2014)


Figure 11. Swiss Pavillion Peter Zumthor (Fletchner 2000)

Questions

Essence:
"The intrinsic nature or indispensable quality of something, especially something abstract, that determines its character"

This thesis takes up some of the timeless questions in architecture. A central question is if materials even have an essence? If so, what is the essence of a material in general and these ones in particular? Does following this essence limit the design? How does a material affect a space?

As essence is an important word, it will also explore what we mean when linking this word to architecture today? How has this view changed over time? How do we achieve this today? Is it even possible with all materials? Do we build according to this "honesty" today?

Today, with all the possibilities digitalisation, manipulation of existing materials and new composite materials offer, this also complicates our view of essence of materials. Can a composite material such as plastic ever be considered the same way as traditional materials such as wood? Does this matter today? How should we relate to materials and essence today?

It is also not certain that this is always desirable, since it can also become a delimitation in the architecture. A material can only be used in a certain way and all other ways are seen as wrong.

The thesis does not investigate sustainability in a deep way, nor the life cycles of the materials. The range of what is possible with a material is huge and there is no possibility to look into all aspects of a material, even less so three, so another delimitation is specific fabrication and assembly of materials.

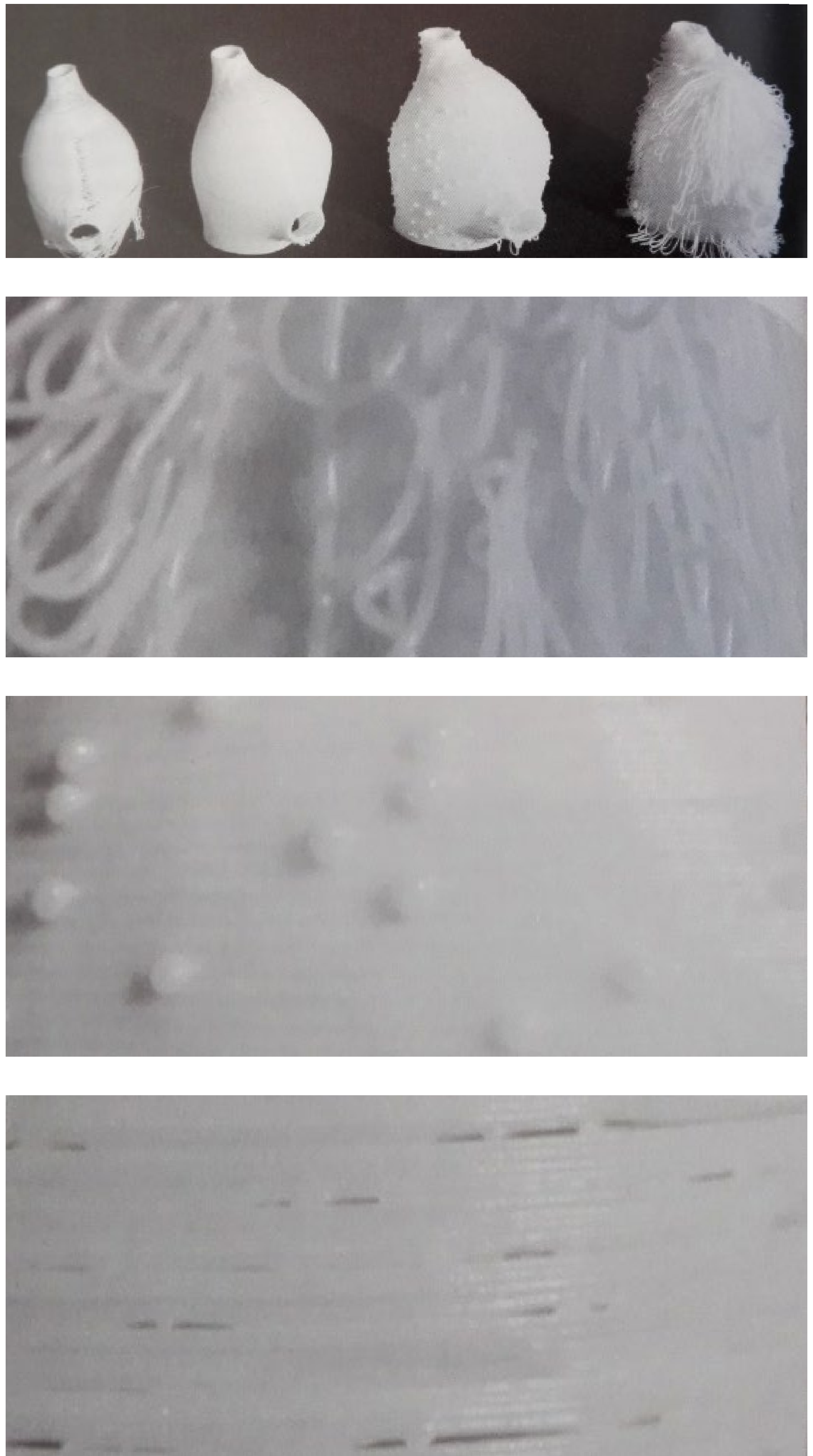


Figure 11– 15. Monolithic processes
ATWOOD (ATWOOD, 2012)

Quotes

The mediation of fabrication technologies has multiplied and fragmented what had seemed to be stable application-traditions: when tree trunks cease to be automatically understood as cylindrical fibrous bundles and can instead be conceived as stacks of veneer sheets laminated without consideration of wood grain, or sawdust molded and pressed togetherwith chemicals to achieve dimensional stability, we find that our nostalgic default material understanding has been fundamentally destabilized.
Gail Peter Borden, Michael Meredith

Our disciplinary challenge today, therefore, is to invent new narratives which helps us make sense of denaturalized, destabilized, and contigent matter-as-material, matter-as-social, and matter-as-fabrication-technologies. Our re-emerging interest in physical form and visceral effects is a way of playing with a post-postmodern need for realism and a post-digital need for quantifiable techniques and evaluation.
Gail Peter Borden, Michael Meredith

On the basis of his taxonomy Semper would classify the building crafts into two fundamental procedures: the tectonics of the frame, in which lightweight, linear components are assembled so as to encompass a spatial matrix, and the stereotomics of the earthwork, wherein mass and volume are conjointly formed through the repetitious piling up of heavyweight elements.
Kenneth Frampton

You say to brick: what do you want brick? And the brick says to you: I like an arch.
Louis Kahn

What shape? Well, the answer lay in the material?
Frank Lloyd Wright

The law goes like this: we must work in such a way that a confusion of the material clad with its cladding is impossible. That means, for example, that wood may be painted any color except one: the color of wood.
Adolf Loos

For architects right up to the present, it has been an intellectual challenge to harmonise the two views of material as such as structural form and material as such as surface.
Ute Poerschke

Do not think about specific materials. Do not think about concrete, glass, or steel; think about material properties: think about heaviness, lightness, translucency, and transparency. Those kinds of properties are much more important than the particular stone you choose.
Stan Allen

Materials

My intention is to use these materials because they are different in many ways. I want to use materials with different types of structural values and fabrication processes, that are not regarded in the same ways in terms of traditions, general love for the material and usage.

Wood (classic, growing)
Wood (I think using massive wood would give the best sort of challenge) is a traditional and, by many, beloved material. It has a certain form (the tree) and is going to be used constructionally in a column-beam structure, vector-active. It carries loads in both tension and compression and is a "living" material from the plant kingdom. Wood has been used a lot in buildings, so there are many available references. Some challenges are the shrinkage and growth depending on moist, absorbation of water and to find stiffness without using an additional material. It is a challenge to join wood without using steel or any additional materials, and perhaps not even desirable. Thanks to digitalisation, there is a great deal of pre-fabrication solutions available on the market, one possibility for me to consider is to use for example CNC as a technique, to use also focus on the fabrication and to use a somewhat modern approach (Zwerger, 2012).

Rammed earth (traditional, increasing populatity)
Rammed earth has been used for a very long time, but is not a very well-used or traditional material in Sweden. Due to sustainability, its popularity is now increasing. It is a natural material which is built in molds, the variation of forming is big.
This material is good at handling compression but not tension and is a heavy material, supposed to give good indoors climate. This means the material has to be form-active, masonry, and that there will be a challenge to create a roof (Easton, 2007).

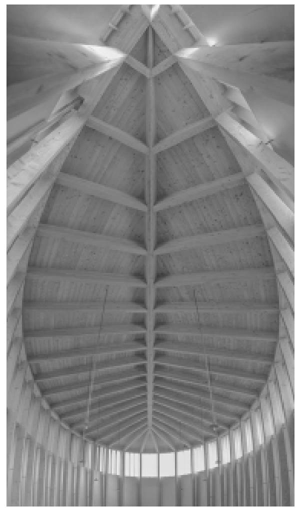


Figure 16. St Benedict Chapel, Peter Zumthor(Camus, 2012)

Figure 17. Nest We Grow, Kengo Kuma (Shinkenchiku-sha, 2015)

Figure 18. Viikki Church, JKMM (de la Chappelle, 2012)

Figure 19. Bruder Klaus Field Chapel, (Amoretti, 2016)

Figure 20. Rauch Family Home, Boltshauser, (Bühler, 2008)

The difference from mud is that rammed earth uses less water, which makes the production velocity faster (Rammed Earth Consulting, 2017). A reason we have not used this material more in Sweden is because our climate provides with some challenges in the fabrication process, but this can be solved.

Plastic ("new", artificial)
Plastic is a relatively new building material, artificial and not very popular among architects. It can be formed in infinite variations, with different methods. The many possibilities with plastic also makes it difficult to define, there are many expressions and forms it could assume. In her essay "Plasticity at Work", Sylvia Lavin compares Louis Kahn's definition of what a brick wants to be with plastic, and argues that plastic does not have such a universal grammar, or truth to material (Lavin 2002). In the essay "Composite Tectonics – From Monolithic Wholes to Manifold Assemblies", the authors means that she is wrong and what plastic would answer to the question is "diversity" (Huljich, Spina 2012). My intended fabrication process is 3d-printing, choosing a method is probably essential for this diverse material. The constructional principle will be surface-active structure, which it in fact wouldn't have to be, the 3d-printing would also suit a form-active construction. The 3d-printing brings different challenges, since the product should be able to be printed at one piece without supports, there can be not overhangs without an inclination of 45 degrees of more (3d verkstan, 2015).

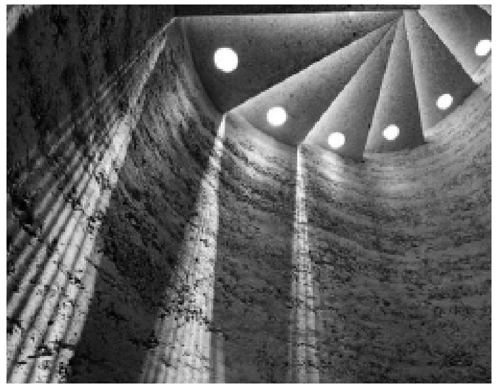


Figure 21. Rauch Family Home, Boltshauser Architekten (Bühler, 2008)

Figure 22. Bruder Klaus Chapel, Zumthor. (Schroeer-Heiermann, 2012)

Figure 23. Bloom Pavilion, Emerging Objects (Millman 2015)

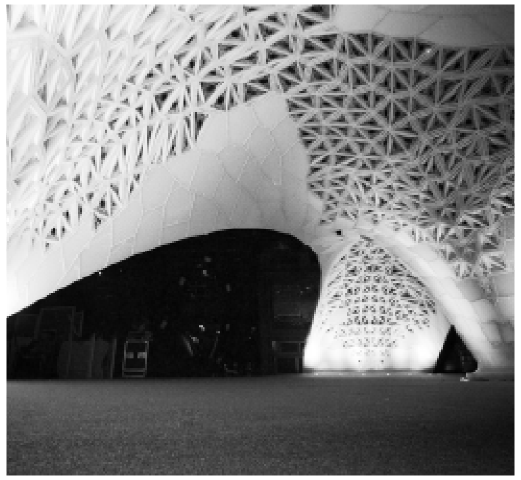
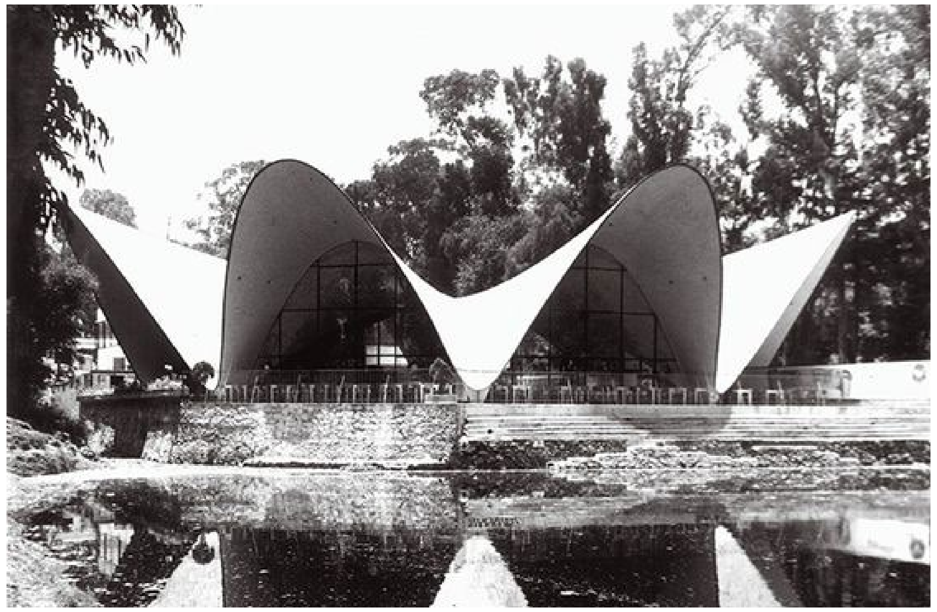


Figure 24. Vulcan, LCD (Designboom 2015) 3D print



Restaurant Los Manantiales, Félix Candela (RIBA Collections, 1958)

Material Facts

	Rammed Earth	Wood	Plastic
Content	Consists of sand, clay (the glue), a little water and sometimes cement. 70 % sand, 30 % glue (clay) (Easton, 2007).	Wood. Natural composite of cellulose fibres (Hickey, 2001).	Artificial material consisting of carbon, hydrogen and oxide. Properties are determined by the structure (Engelsmann, Spalding, Peters, Stein, 2010).
Fabrication	Built in molds. Packed layer by layer into a solid mass (Easton 2007).	There are different fabrications for wood, sawing, drying and refining tree trunks or assemble saw dust or cross laminate timber into sheets (Zwerger, 2012).	Different types: molds, 3D-printing, SPIF, vakuum forming etc. My focus is on 3D printing. 3d printing is usually done with a thermoplastic form of plastic, with uncross-linked structures (Engelsmann, Spalding, Peters, Stein, 2010).
Origin	Evidence of nearly 1000-year-old buildings in rammed earth in the Middle East and Northern Africa. Later spread to colder climates aswell (Easton, 2007).	Wood has been used where there are trees, in Scandinavia, Japan etc. Even in Iceland, which has no trees (Zwerger, 2012).	First used in architecture in the 50's. The ground for the high-performative composites we use today was layed in the 40's (Engelsmann, Spalding, Peters, Stein, 2010).
Strength	Good at carrying in compression, 4.3 MPa (Cassel, 1993). Good thermal values. Sustainable. Easy to find. Short drying time compared to similar techniques. Easy to build for unskilled workers (Easton, 2007).	Good at carrying in tension. Accessible and renewable. Easy to find and refine. Appeals to more senses than eyes - smells, makes sounds, tactile (Zwerger, 2012).	Very strong (in tension especially) compared to its weight. High performative, weather-resistent. Very formable. Diverse (Engelsmann, Spalding, Peters, Stein, 2010). All pieces can be assembled from the beginning (3d Verkstan, 2015).
Limits	Can only carry in pressure without reinforcement. Not water resistent, but depends on type of soil and compactness. Corners are difficult to build and weak. Openings and roof constructions are complicated to build (Easton, 2007).	Very sensitive to mould and humid, grows and shrinks depending on water. Different pieces of the tree trunk are of various quality. Not so fire resistant (Zwerger, 2012).	Difficult to control - needs testing. Bad fire resisting properties. Not so rigid - needs framing, folding or curving (Engelsmann, Spalding, Peters, Stein, 2010). 3d-printed plastic can't cantilever, needs an angle of 45 degrees (3d Verkstan, 2015).
Details/Assembly	Solid mass, with clay as glue (Easton, 2007).	The different pieces have to be assembled with some kind of joint, like screws or nails. Combination with interlocking systems? (Zwerger, 2012)	All pieces can be assembled from the beginning in 3d printing (3d Verkstan, 2015). Melting or joining is also possible (Engelsmann, Spalding, Peters, Stein, 2010).
Density	Heavy, but depends on how "rammed" the earth is. Concrete is usually ca 2400 kg/m^3, as a reference (Wilby, 1983).	Ca 300-800 kg/m^3 when dry (Bodin, Hidemark, Stintzig, Nyström, 2013).	Ca 1200 kg/m^3 for polycarbonate. Other types of thermoplastics have lower density (Engelsmann, Spalding, Peters, Stein, 2010).
Spans	- Can be built as arches (Rammed Earth Consulting, 2017).	Less than 30 meters for glue laminated straight beams. Less for wooden beams, depends on cross section (Bodin, Hidemark, Stintzig, Nyström, 2013).	Examples of over 10 meter spans, but can be much longer (Engelsmann, Spalding, Peters, Stein, 2010).

Method

In order to get a definition of essence in materials, the study begins with a literature study on this topic. These aspects are brought into the typology of the investigation, which is a Friggebod. The Friggebod can beseen as the Primitive Hut of our times, it is a small and basic building with no need of permission to build. They are available to purchase in most building stores, so this Friggebod is one of the simplest available in the store Byggmax, called Peter – 10. A number of features, such as height, length, width, eaves, openings etc, areselected and a part of all three versions. The versions differ in similarities and construction, surface and meetings, which is mainly investigated in physical models, in iterations between 1:50 and 1:20.

These studies show restrictions and possibilities with the different materials, for example how to make an cantilevering eave with rammed earth or the fact that 3d-printing is only possible on a 45 degree angle (or more) (3d verkstan, 2015). The materials are also combined with structural principles. The three basic structural principles are brought up by Heino Engels in Tragsysteme as vector-active (linear elements, tectonics), which is suitable for wood that is not manipulated in any way, sticks, form-active (masonry, stereotomy) (Engels, 1968), which is the only way to use rammed earth, since it only works under compression and with thick elements and surface-active (sheets), which is used with the 3d-printed plastic.

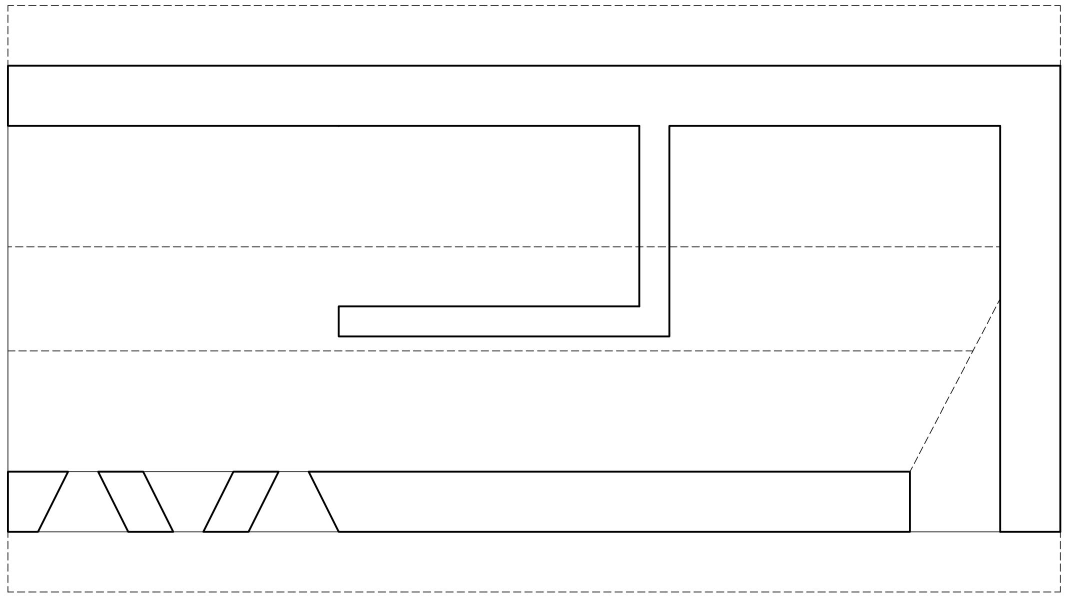
The three studies are eventually combined into one final composite version of the Friggebod, showing the materials' pecularities and qualities and how they can be combined.

Process
Iteration 1–7

The design process begins with a first iteration of a Friggebod in the three materials. There are not yet any rules so the different versions are quite free in their design compared to each other. They are of the same size with a pitched roof.

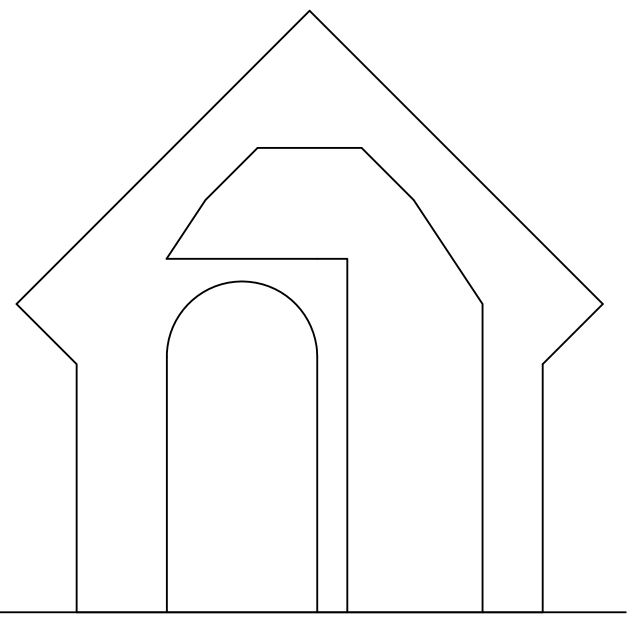
Generation 1
Rammed Earth

Generation 1
Rammed Earth



Plan 1:50

Elevation 1:50



Section 1:50

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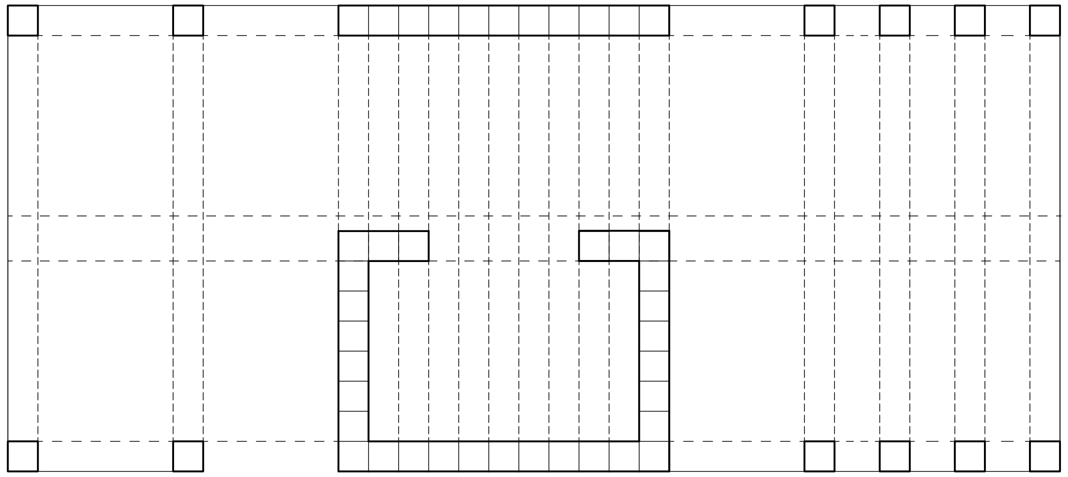
Generation 1
Wood

Generation 1
Wood



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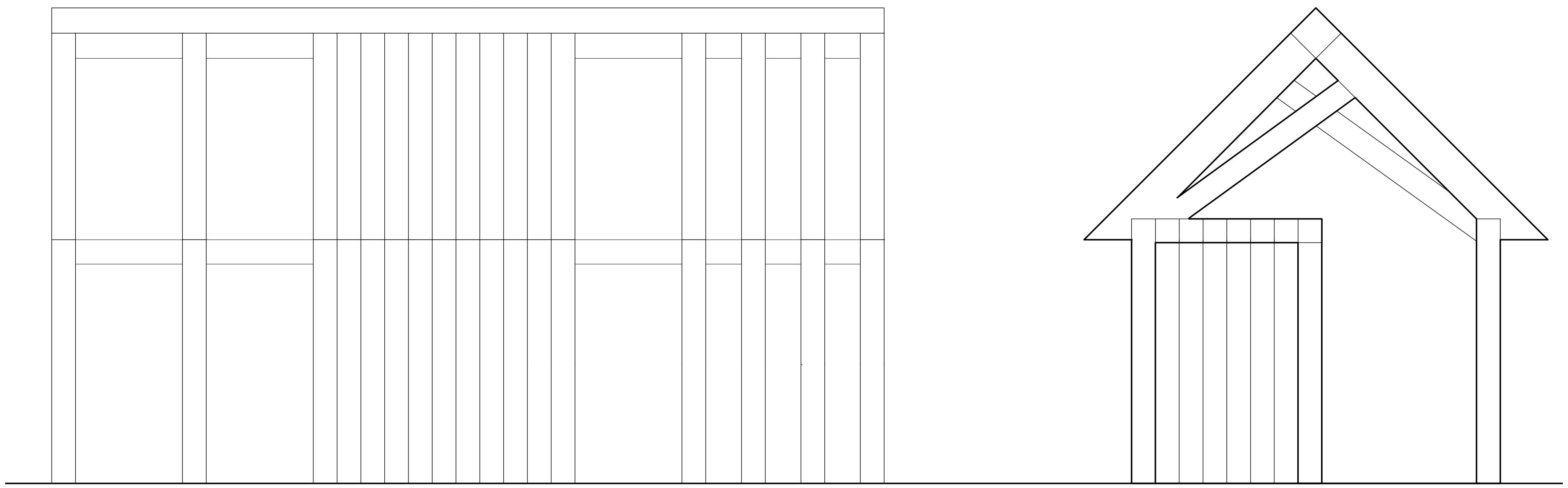
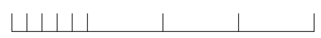


Elevation 1:50

Section 1:50



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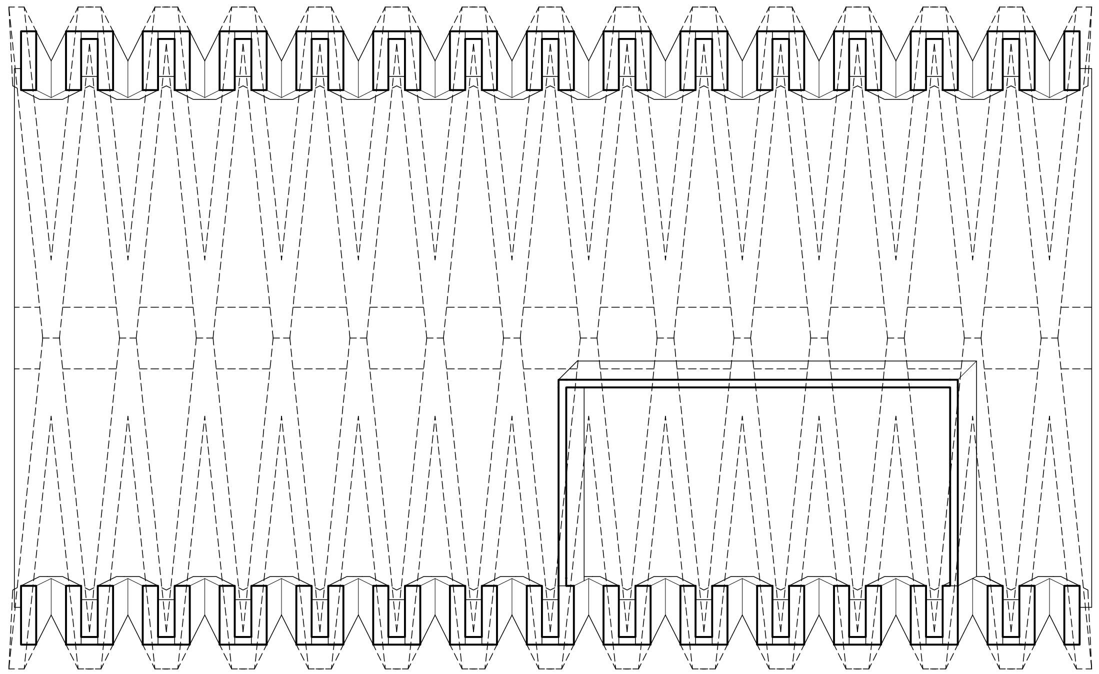
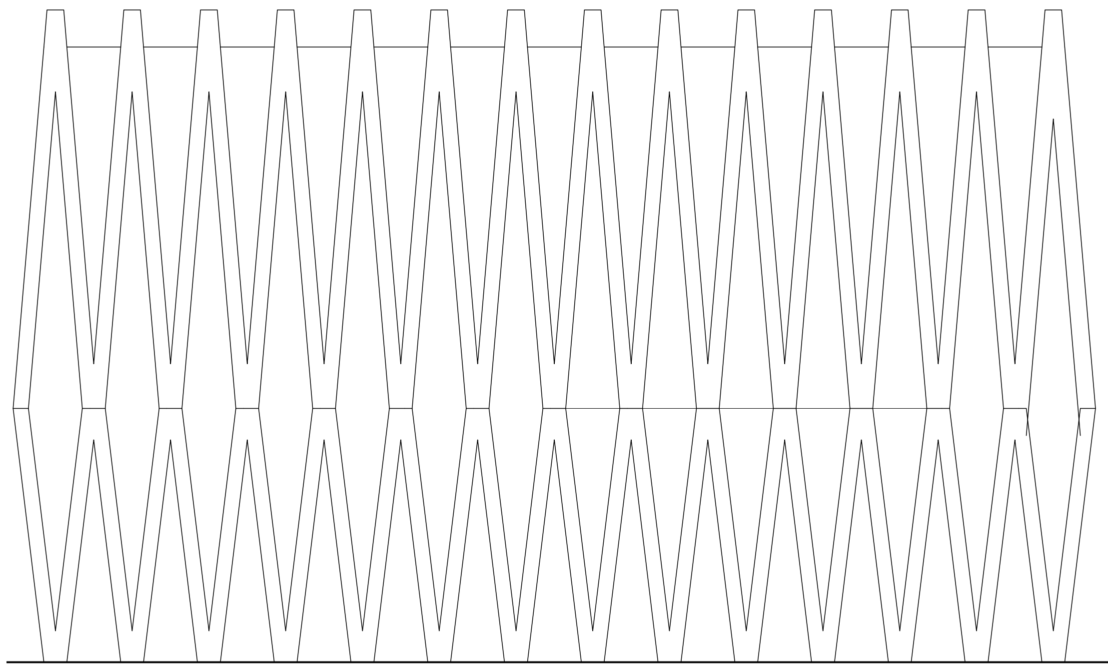
Generation 1
Plastic

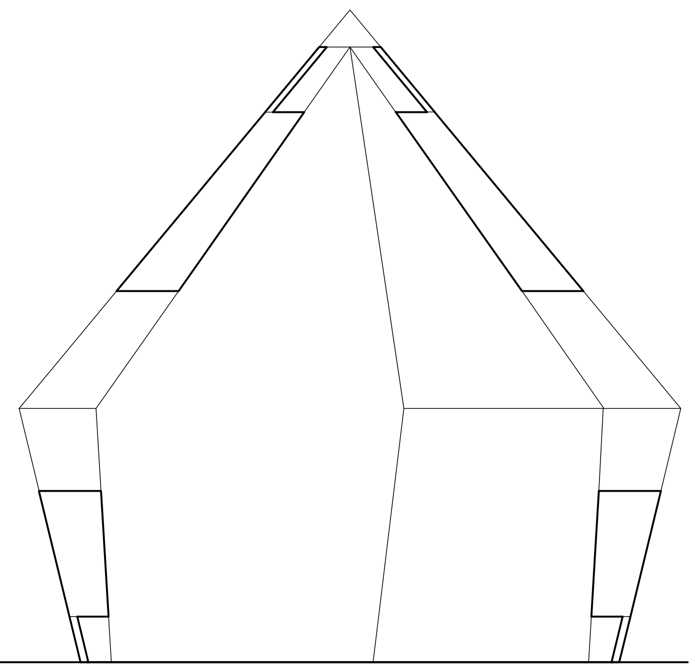
Generation 1
Plastic



Plan 1:50



Elevation 1:50



Section 1:50

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Generation 1
Summary/Findings

The rammed earth test shows that the arched construction works, as well as the design for the eaves.

The pointy window worked out fine and gives a beautiful trailer light. The other windows did not work as planned, however, the distance between them has to be bigger to work structurally. The window stealths are something to work with, though.

The precision with the rammed earth is not 100 %, at least not in this scale. The corners are a bit rounded and the surface not smooth, because it is very difficult to ram the earth all the way out in the molds.

I need to make some more decisions regarding the wood. Between the sticks there should be something that makes walls – sticks or sheets.

This model is not structually stable and has no design on how to meet the ground – which should be more determined in the next iteration.

The vector-active construction can be beautiful, but it will also be classic in a way, this shape is classic for this sort of construction, so pushing the design beyond that is a challenge.

After this test, the plastic construction seems a bit too much like the wooden construction. I should work more with sheets; the challenge is to make it stable.

The fact that this was 3d-printed without supports is, however, a success. The pointy openings is a good way to make openings that can be 3d-printed.

Generation 2

In the third iteration the scale went up to 1:20 with a more detailed approach, focus lay on surfaces, textures and openings. Models were made of a wall (with ceiling construction) and in the renderings this was combined with a more spatial focus.

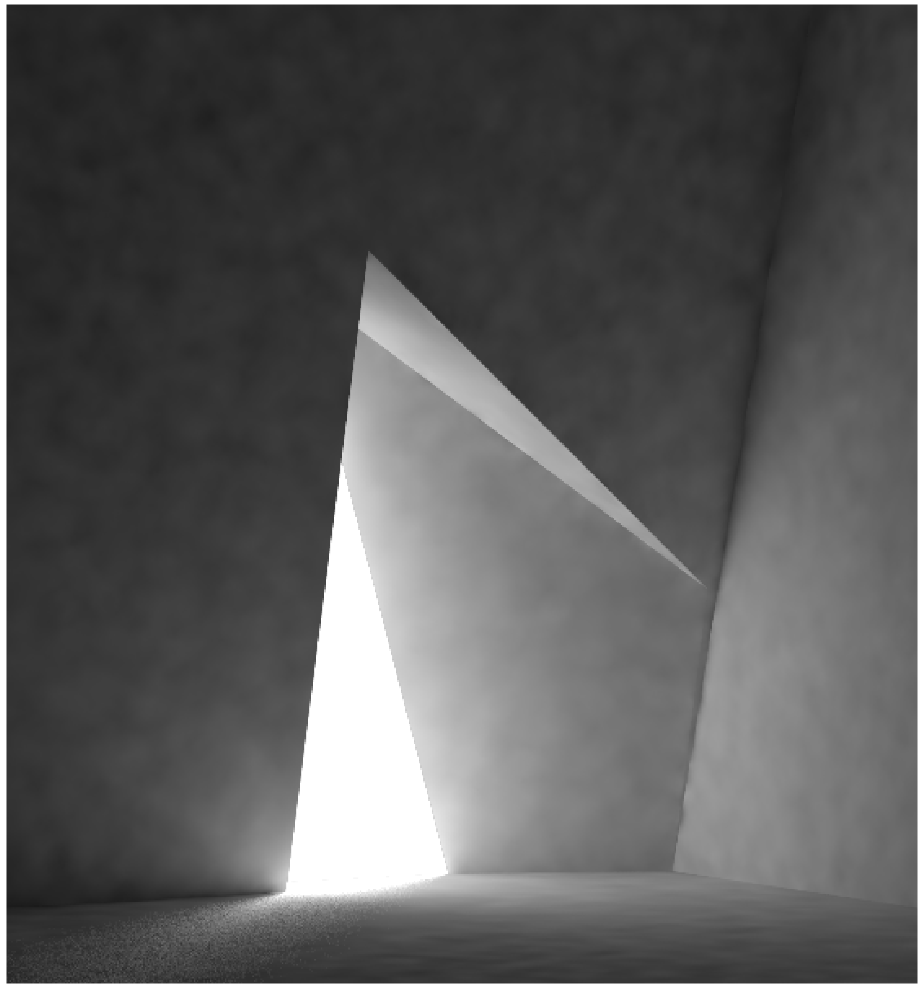
The restrictions of each material (and construction) gives different limitations and possibilities to the design:

Rammed earth: Openings has to be pointy or rounded to carry the load in compression. The thick walls give possibilities to work with angled window stealths. The texture depends on the moulds, can be patterned in different ways. There is also a possibility of colour. The roof is a problem, like openings it has to be pointy (like in this try) or arched (like last week).

Wood: Openings can only be between load bearing elements. Light and construction can be combined in nice ways. Texture can be ornaments (”kaplastavar”, sheets), openings or planks, etc. Roof construction this week is beams in a hierarchy.

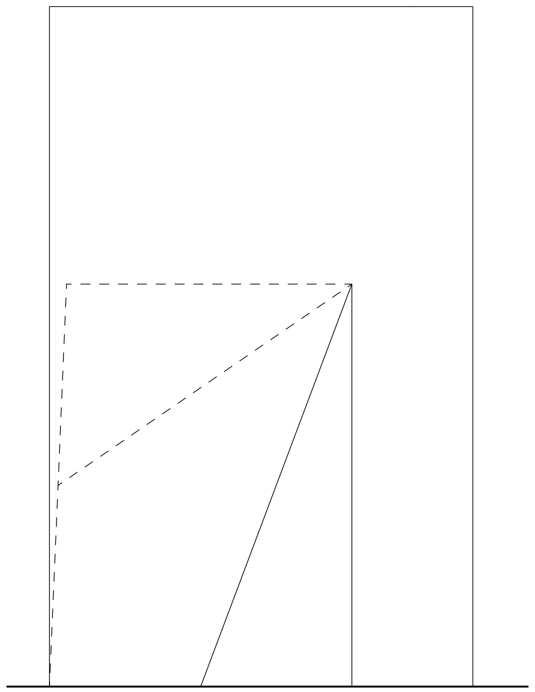
Plastic: Openings and roof has to be leaning at least 45 degrees to manage the 3d printing without supports. For a wall to be balanced it has to be folded, curved or have more plastic added in strategic places. The openings can be completely random since the load bearing system is not dependent on repetition (compare with wood), why the openings of the design are ”random”. The surface can be textured in different ways, as long as it handles the 45 degrees angle rule.

Generation 2
Rammed Earth

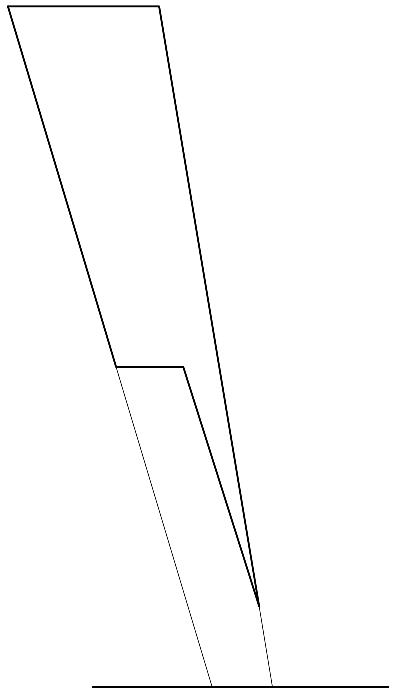


Generation 2
Rammed Earth

Generation 2
Rammed Earth



Elevation 1:50



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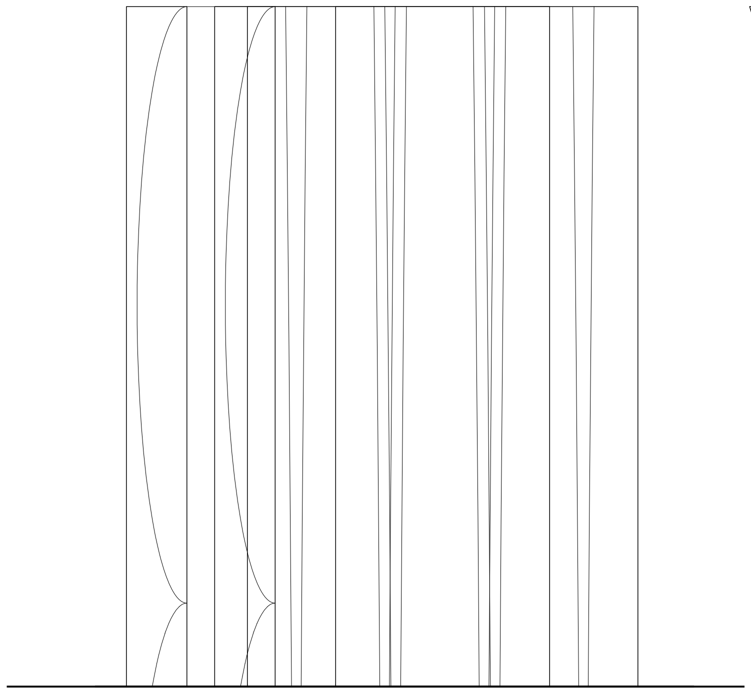

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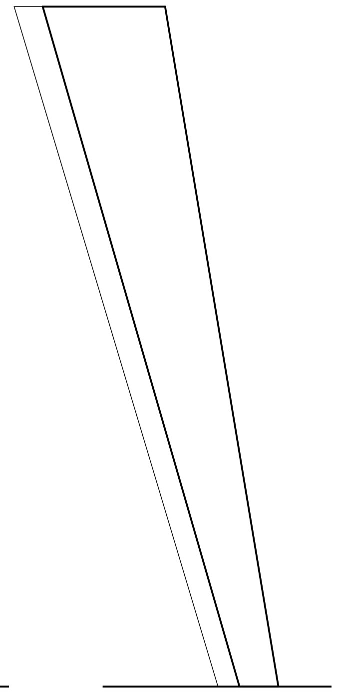

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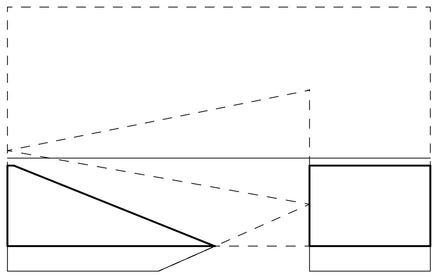
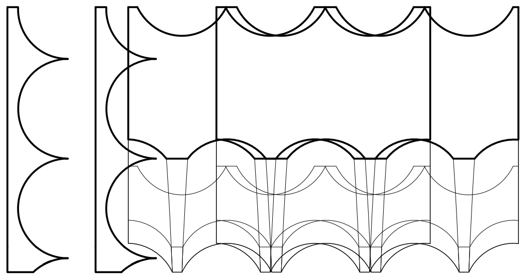


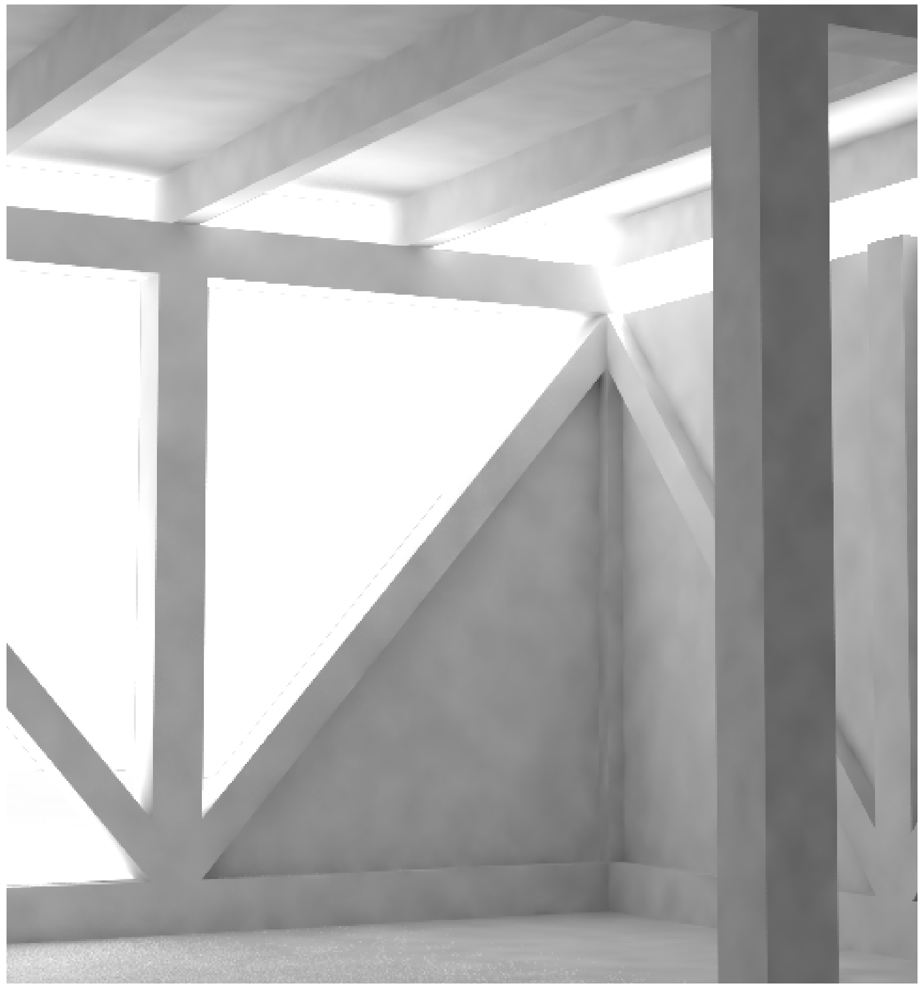
Plan 1:50

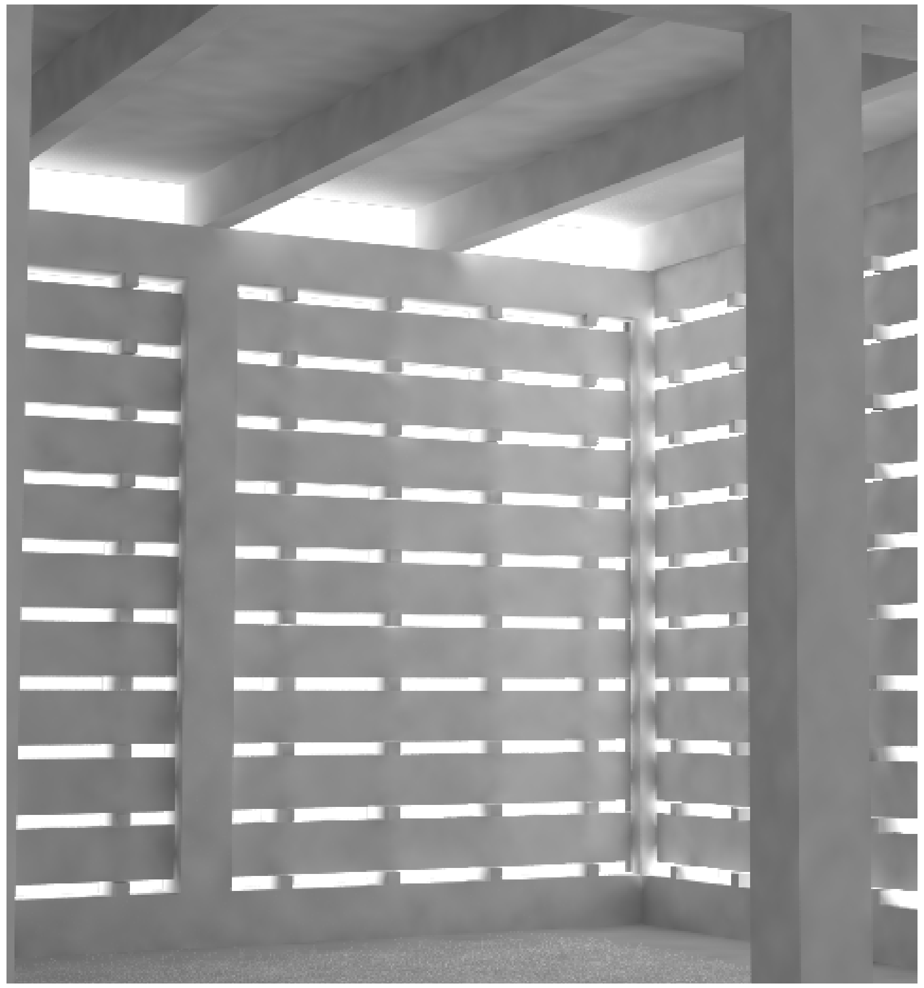


Plan 1:50

(A3)

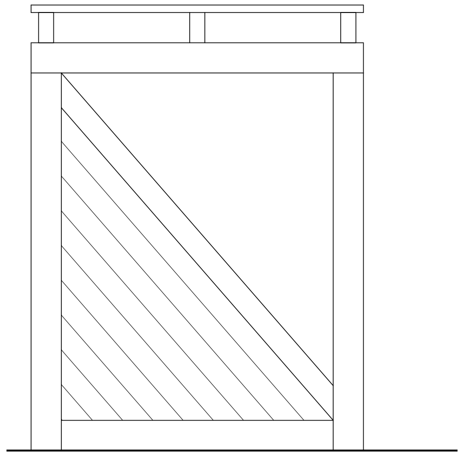
Generation 2
Wood

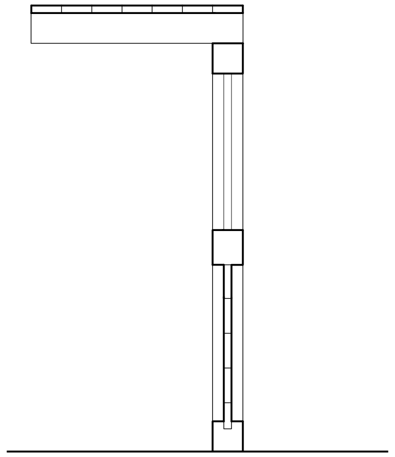




Generation 2
Wood

Generation 2
Wood


Elevation 1:50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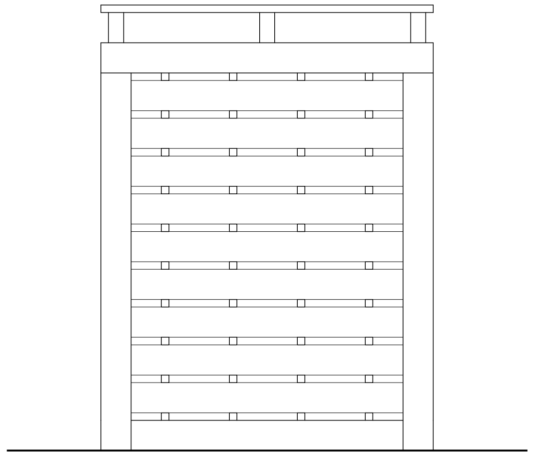
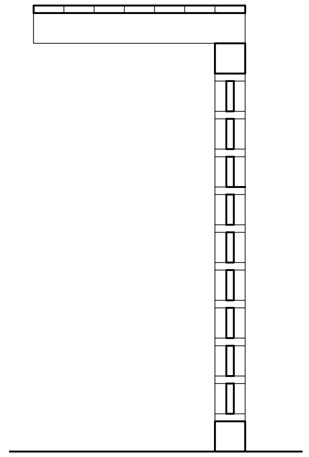
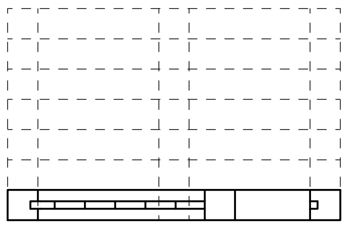
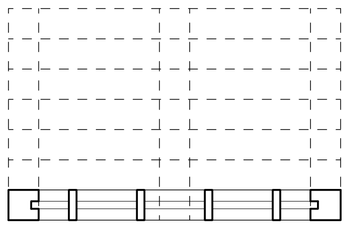

Elevation 1:50

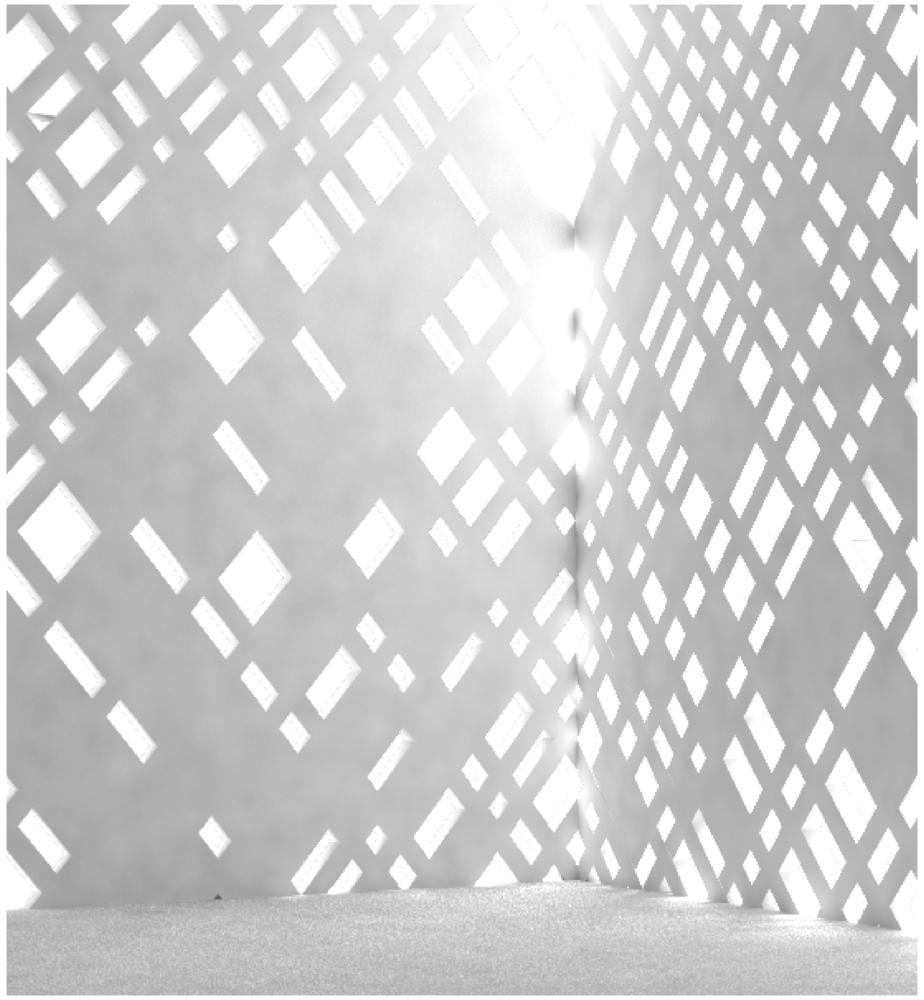

Section 1:50


Plan 1:50


Plan 1:50

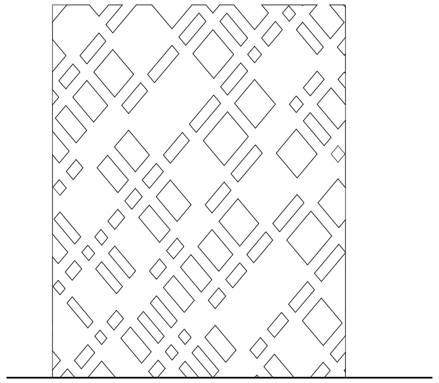
(A3)

Generation 2
Plastic

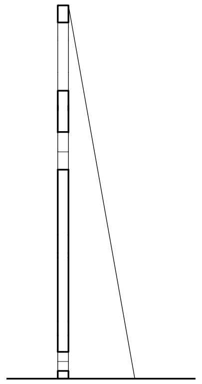


Generation 2
Plastic

Generation 2
Plastic



Elevation 1:50



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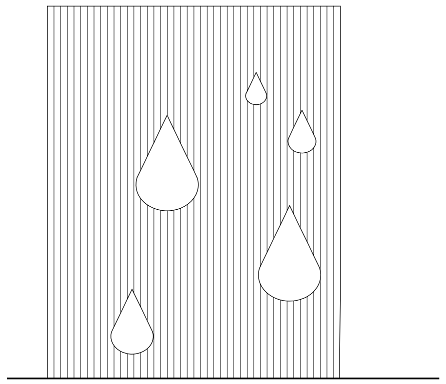

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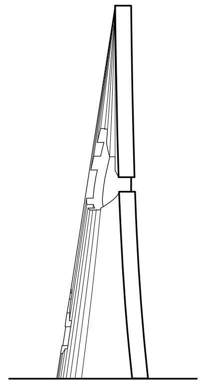

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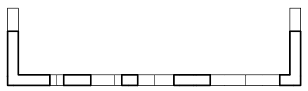
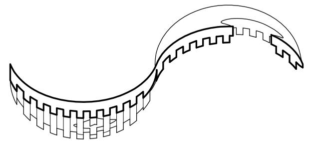


Plan 1:50



Plan 1:50

(A3)

Generation 2
Summary/Findings


The first rammed earth study was of an opening with a very defined window stealth. Although the mold was difficult to make (3d print in the future?) the test was successful. It was a nice way to make the opening a bit more interesting.

The other study was also quite successful, with light coming in in the corner, shining on a pattern. The pattern was not as defined as wished, how to work that out with the molds?

The coloration was successful as well.


When working with a vector-active construction, the light comes in between the structural parts.

Study one shows how the surface and the openings stabilize the construction, by being diagonal.

The second test shows a pattern referring to the way light is taken in between the beams, it gives a nice light but is not structural.

How to bring these two tests together is not clear, but both are interesting on their own.


Curving the sheet to stabilize it was good, it was stable when 3d-printing, so I think the sheet can be thinner. The drop-shaped windows work fine for showing the free shapes the 3d-printer can make.

Patterning the surface, either with structure or openings works fine, this can obviously be more developed with what it can be.

The second study would be much more interesting if it was thinner, how thin can you go?

Generation 3

Rules for starting point of Generation 4, which is the friggebod Peter 10 from Byggmax (a Swedish version of Home Depot).

Size: 2490 x 3850 millimeters. Height: 2970 millimeters (by the ridge).

Eaves: 300 millimeters on long ends, 250 millimeters on short ends.

Pitched roof

Dubble door (1600 x 1850 mm) on one of the short ends, single door

(800 x 1850 mm) and small window (500 x 500 mm) on one of the short ends, placed in the same positions.

Extra marked rafters by the short ends.

Figure 26. Peter-10 (Byggmax, 2017)

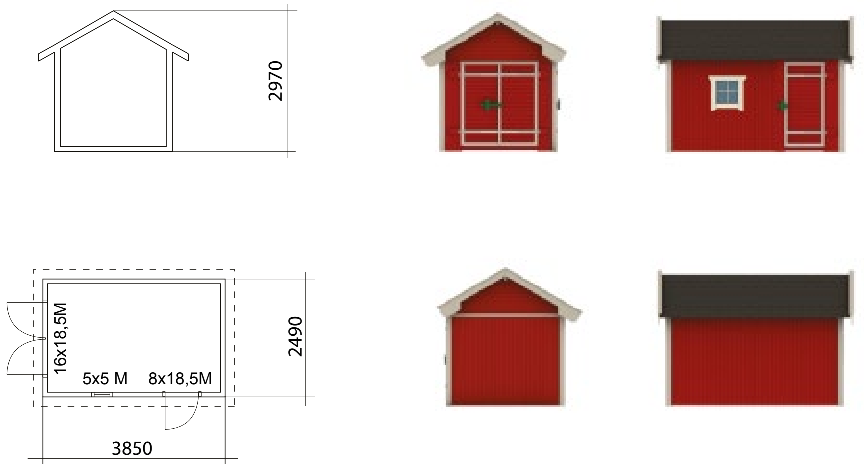
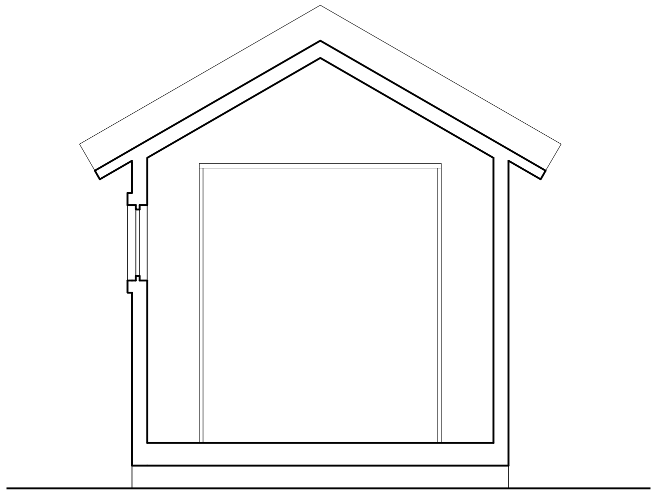
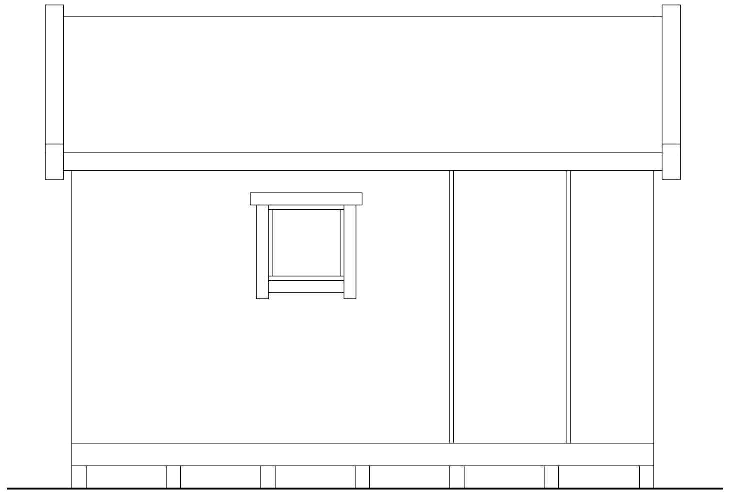


Figure 27. Peter-10 (Byggmax, 2017)

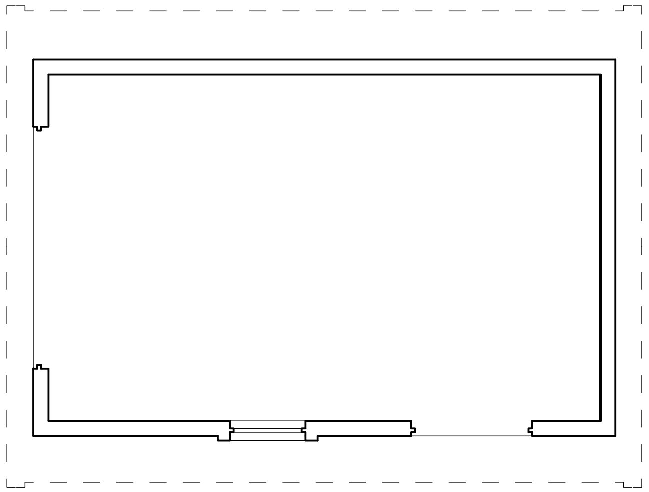
Generation 3
Peter-10



Section 1:50



Elevation 1:50

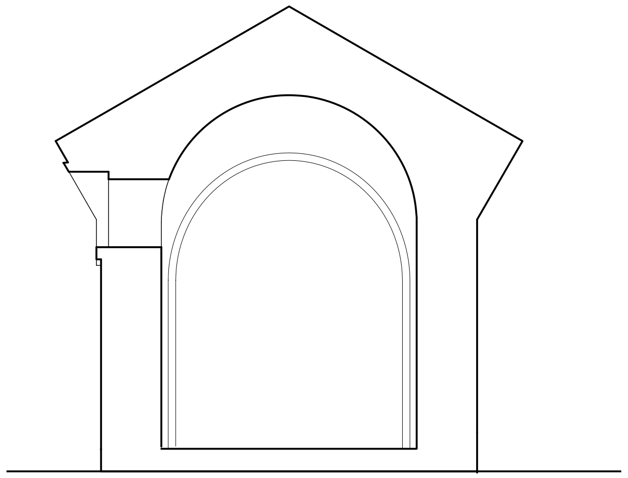


Plan 1:50

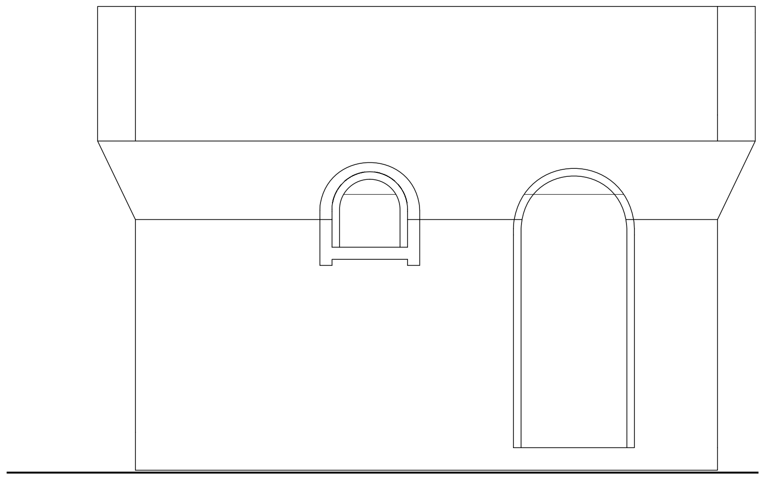
(A3)

Generation 3
Rammed Earth

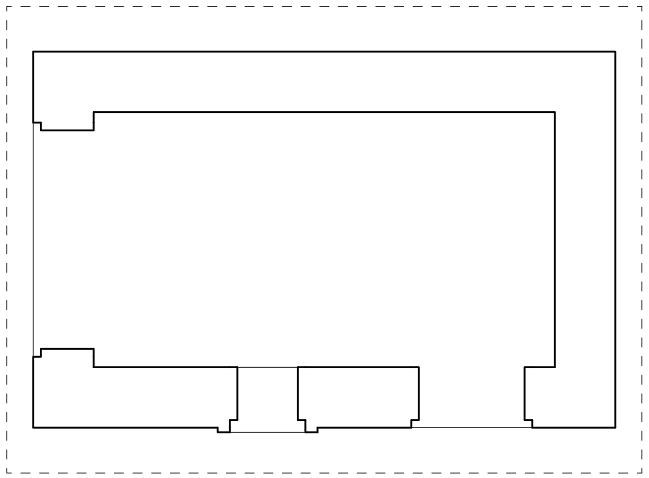
Generation 3
Rammed Earth



Section 1:50



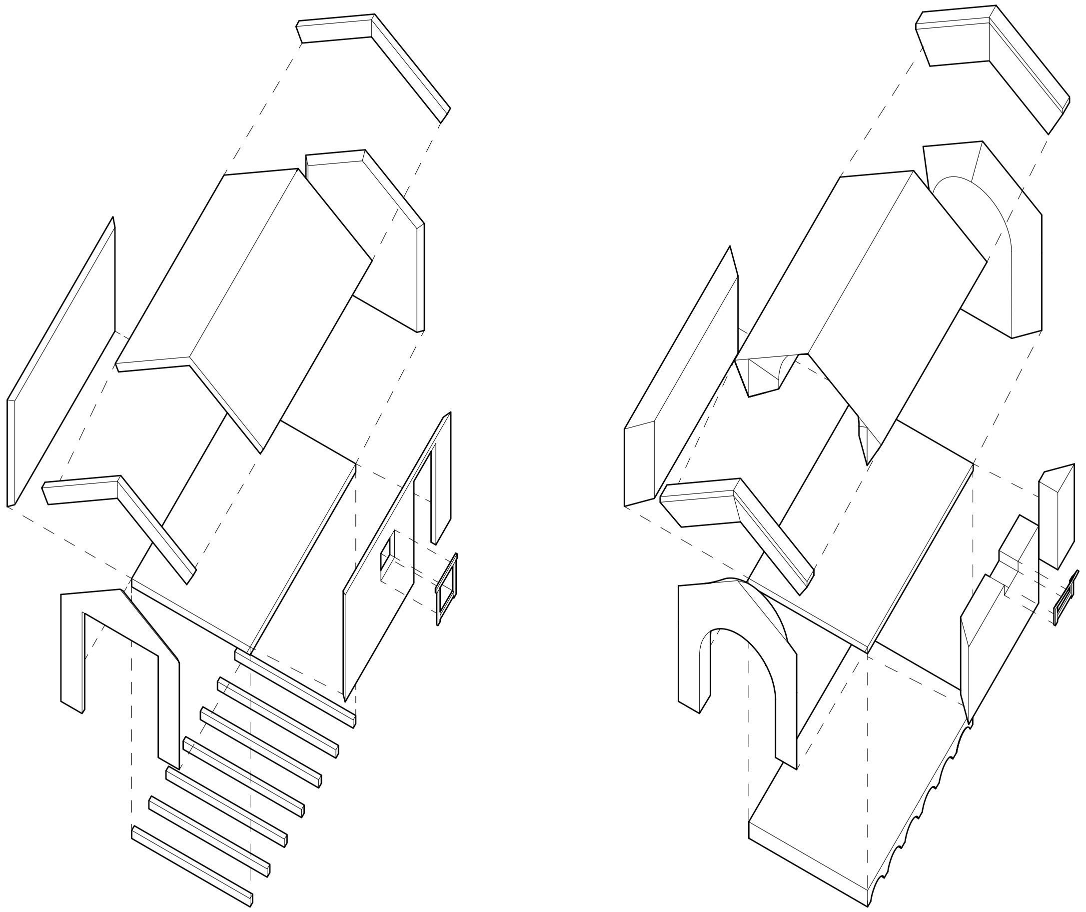
Elevation 1:50



Plan 1:50

(A3)

Generation 3
Rammed Earth



ROOF
The roof can handle the original angle but the elements need to compensate for not managing tension

EAVES
Rammed earth cannot handle cantilevering so the eaves need an angle to manage

INNER SHAPE
The rammed earth has an arched inner structure to carry as little in tension as possible

WALLS
The walls in rammed earth has to be thicker to carry the heavy load from the roof

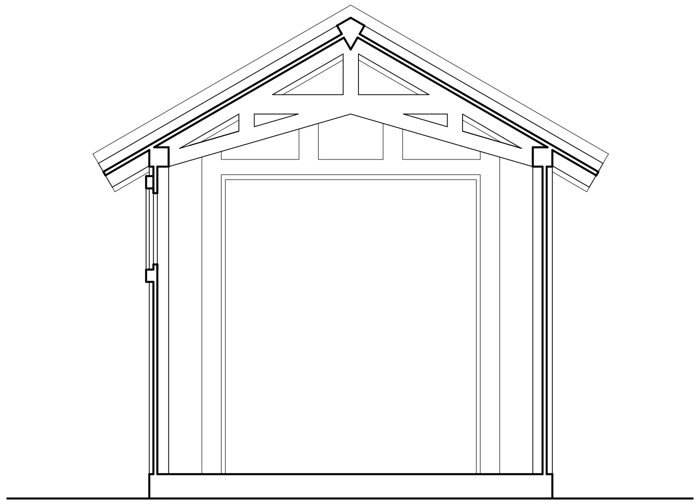
WINDOW
The eaves needs an angle, and come down further, so the window of the rammed earth is in the seam between the eave and the wall, and is partly angeled

OPENINGS
The rammed earth has arched openings to carry as little in tension as possible

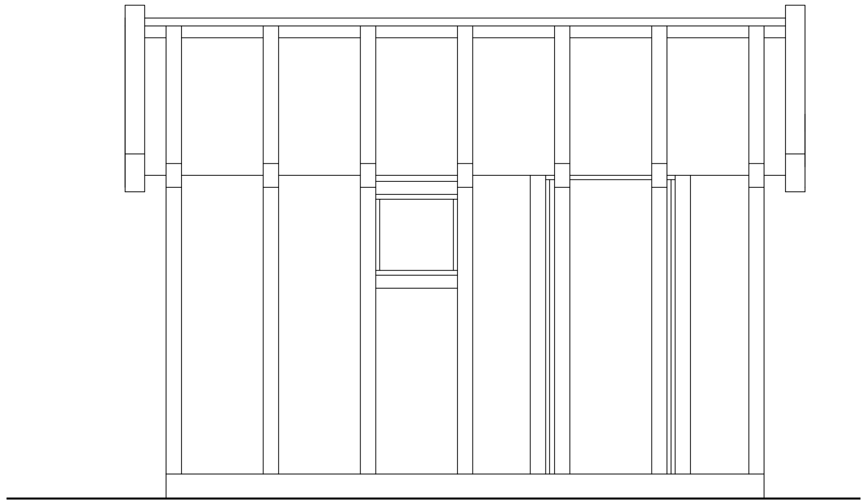
FOUNDATION
The rammed earth has arches instead of plinths to carry as little in tension as possible

Generation 3
Wood

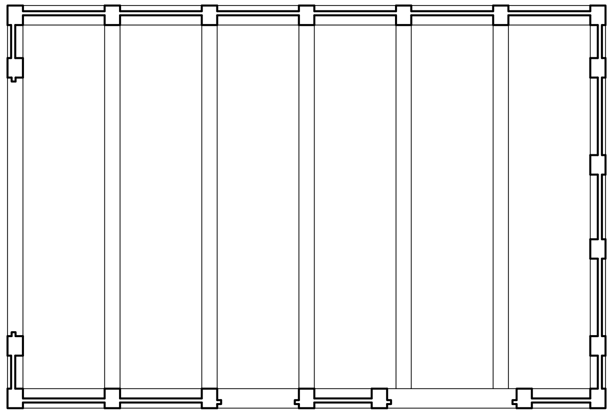
Generation 3
Wood



Section 1:50



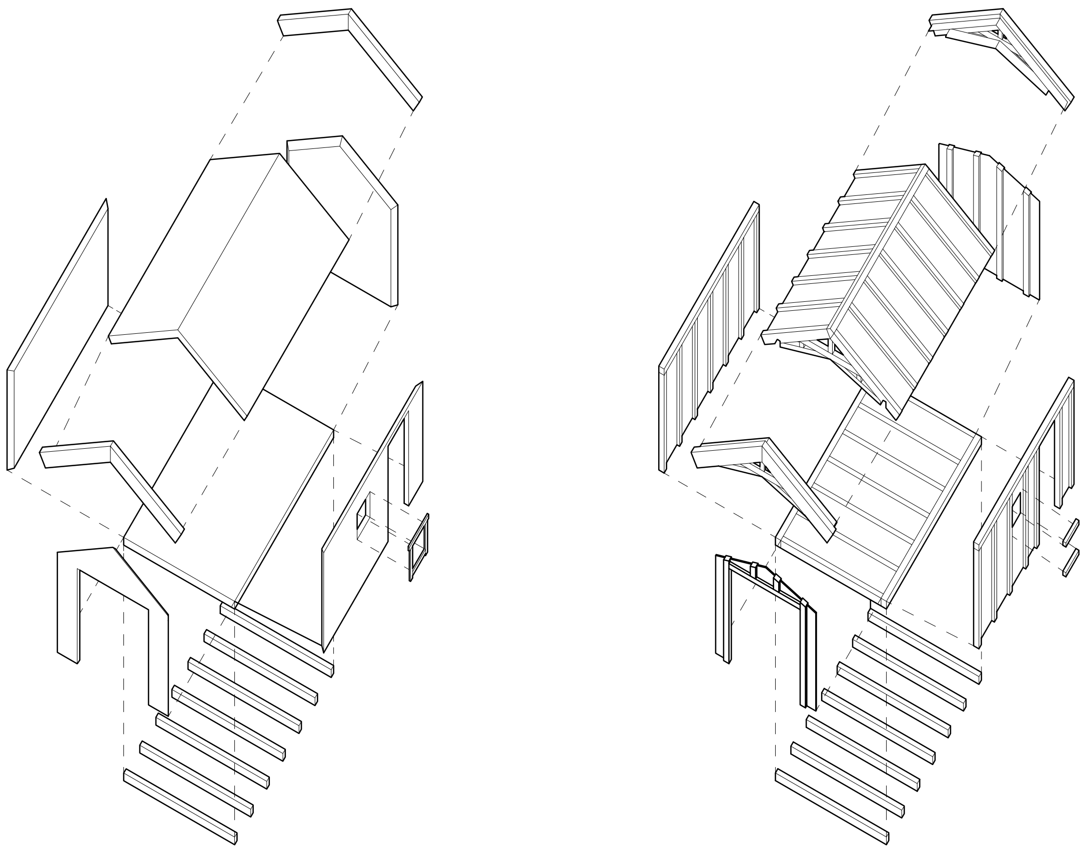
Elevation 1:50



Plan 1:50

(A3)

Generation 3
Wood



ROOF
The roof can handle the original angle but to manage the span the truss needs an inner structure

EAVES
Wood can handle the original eave structure

INNER SHAPE
To manage an acceptable headroom, the truss gets a structure with angeled stabilizing beams, a so-called scissors truss

WALLS
The wall structure is made of columns with boards filling the voids

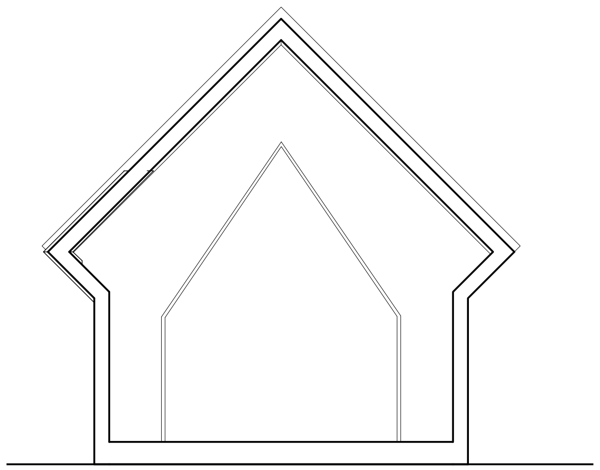
WINDOW
The window is placed between two columns, in the same position as the original

OPENINGS
The wider opening is straight, between two columns with a beam above, to redistribute the load above the opening

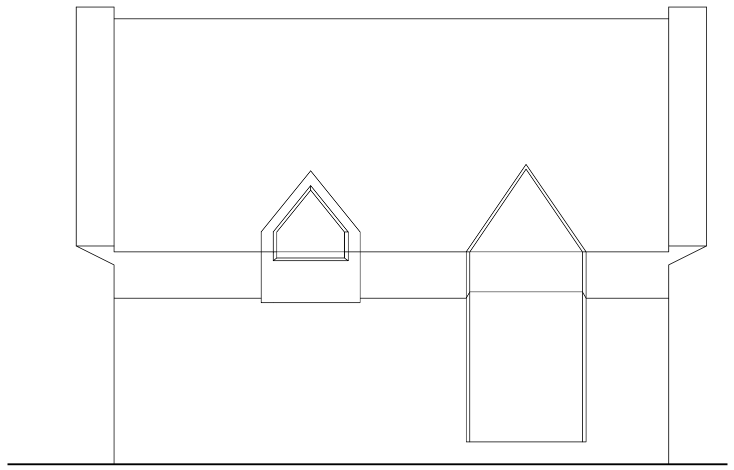
FOUNDATION
The wood foundation is a classic plinth foundation, similar to the original

Generation 3
Plastic

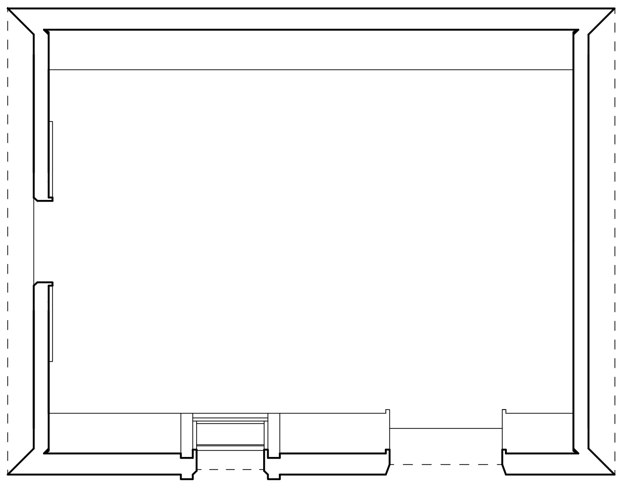
Generation 3
Plastic



Section 1:50



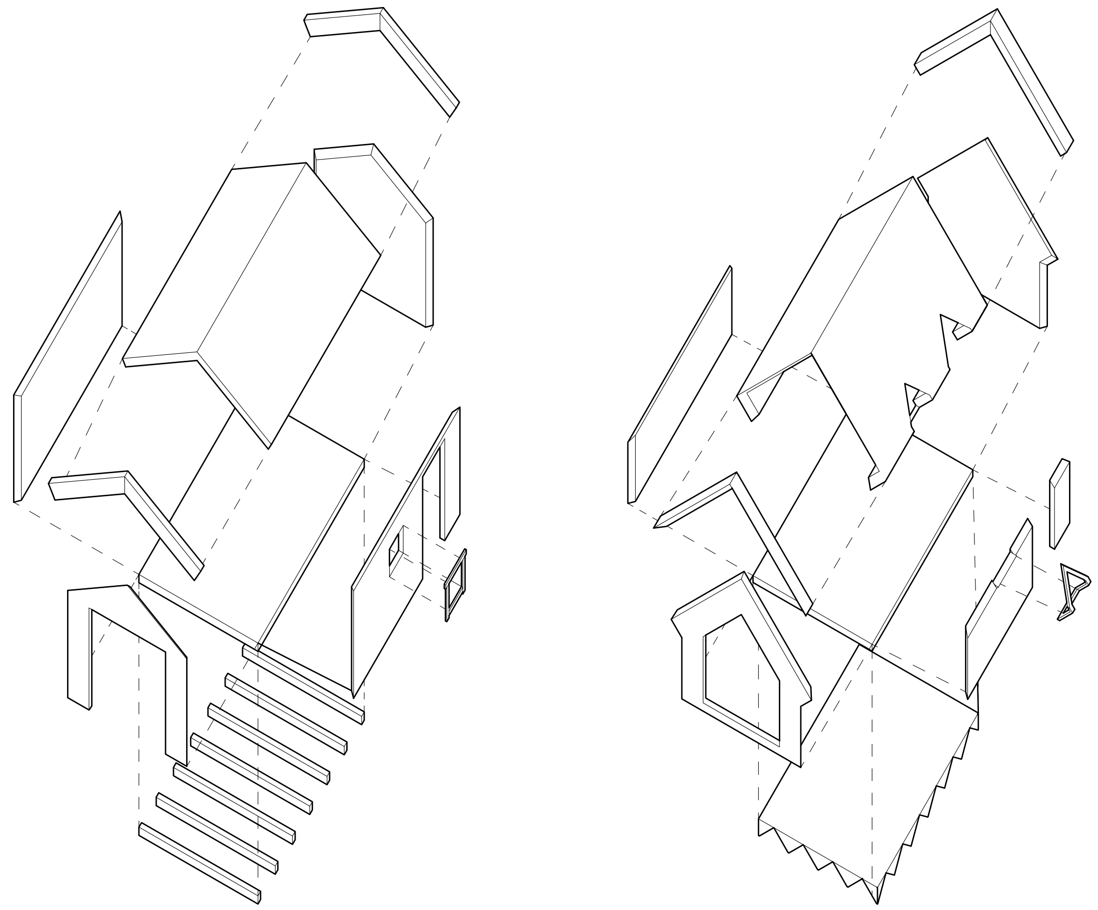
Elevation 1:50



Plan 1:50

(A3)

Generation 3
Plastic



ROOF
The 3d printer can only handle an angle of 45° or more, so the angle of the roof is changed

EAVES
The eaves also need a 45° angle to cantilever

INNER SHAPE
The surface-active structure gives the inner structure a shape corresponding to the outer shape

WALLS
The plastic walls can be very thin, since the whole structure is very light

WINDOW
The bigger angle of the roof and eaves makes the window placed in the seam between the roof and the eave

OPENINGS
The openings, too, need a 45° angle to be 3d-printed without supports

FOUNDATION
The limitation of 45° is applicable also with the foundation. To save material, the foundation is angeled in 4 directions.

Generation 5 is the same Friggebod as in Generation 4, but this time, there is a zoom-in on a section by the window, 695 mm wide. New, more detailed rules are added:

Surface: A rectangular, "wood planks" surface pattern is added to all materials, by the wall and the roof.

Meeting with ground: Plinth foundation

Marked frame around window, a bigger one outside of the opening, a smaller one inside the hole, as the frame where the window would be attached.

The old rules still apply.

Figure 28. Peter-10
(Byggmax, 2017)

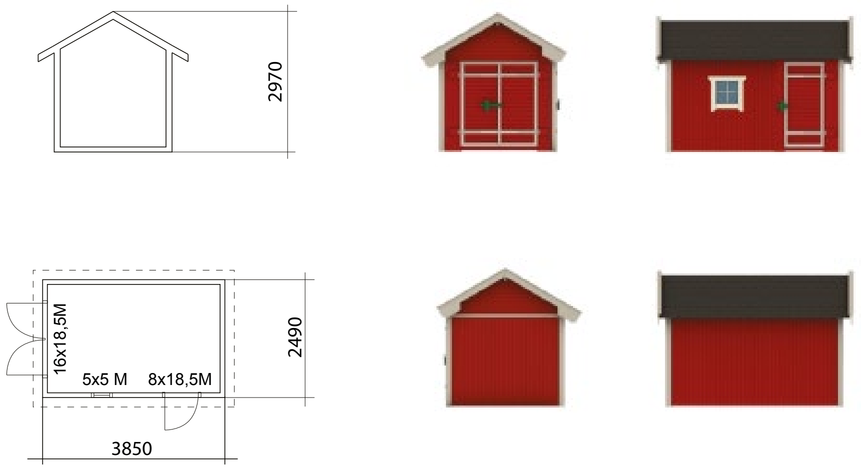
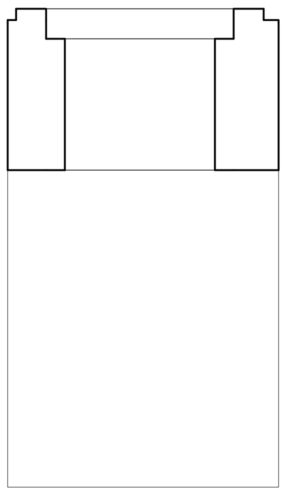


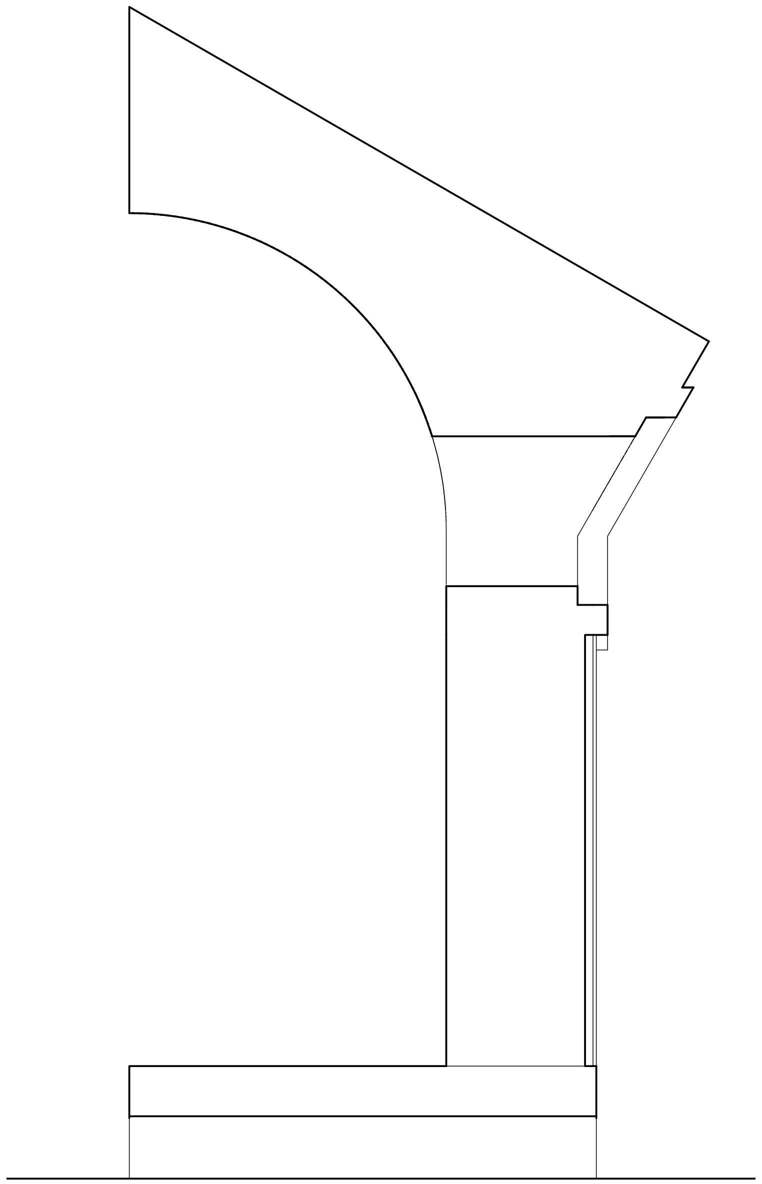
Figure 29. Peter-10
(Byggmax, 2017)

Generation 4
Rammed Earth

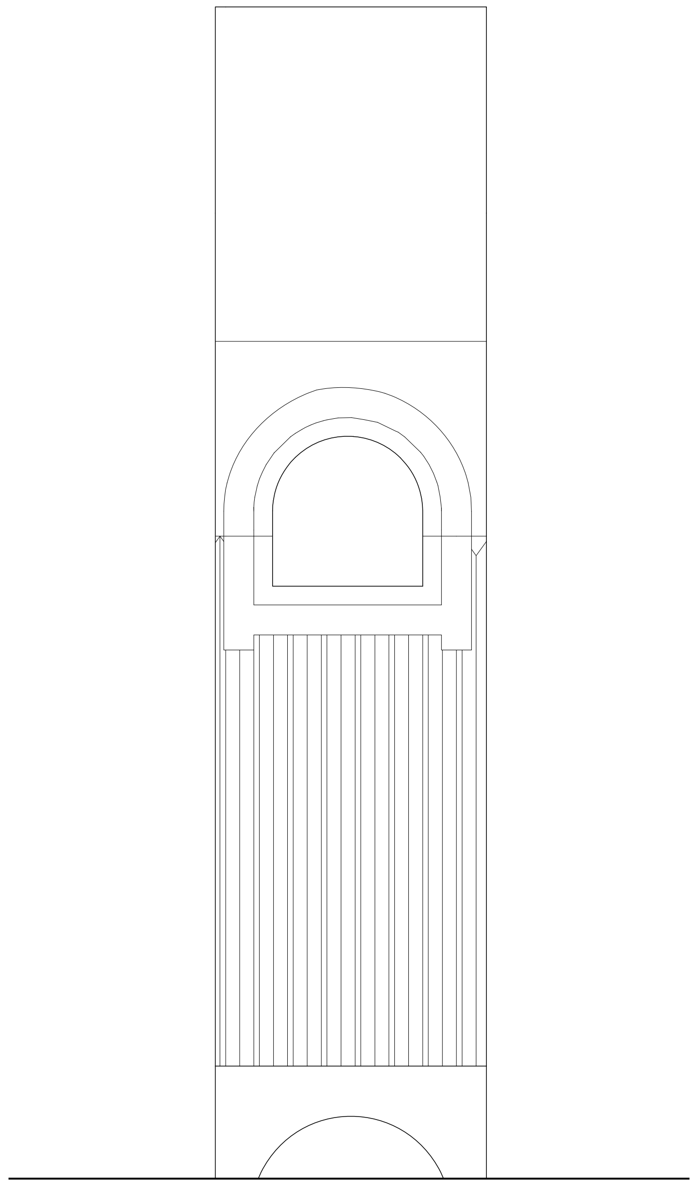
Generation 4
Rammed Earth



Plan 1:20



Section 1:20



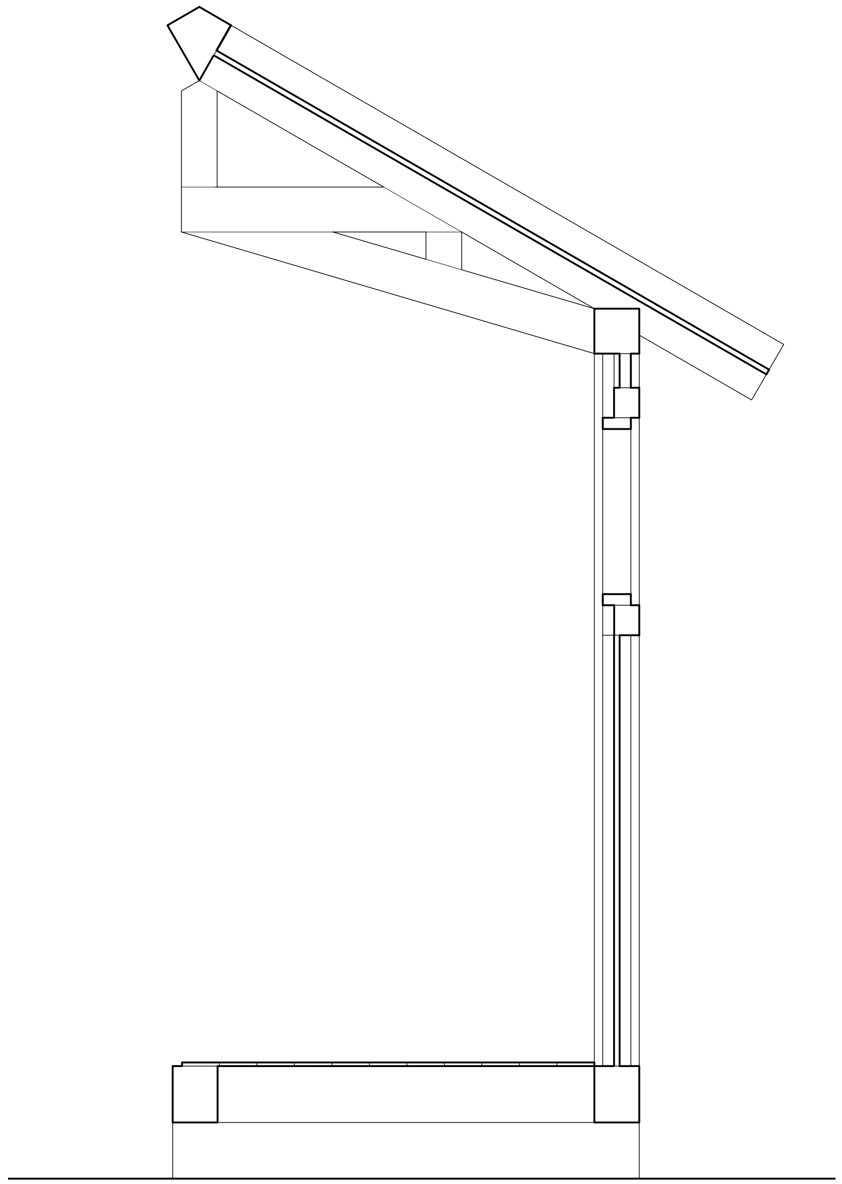
Elevation 1:20

(A3)

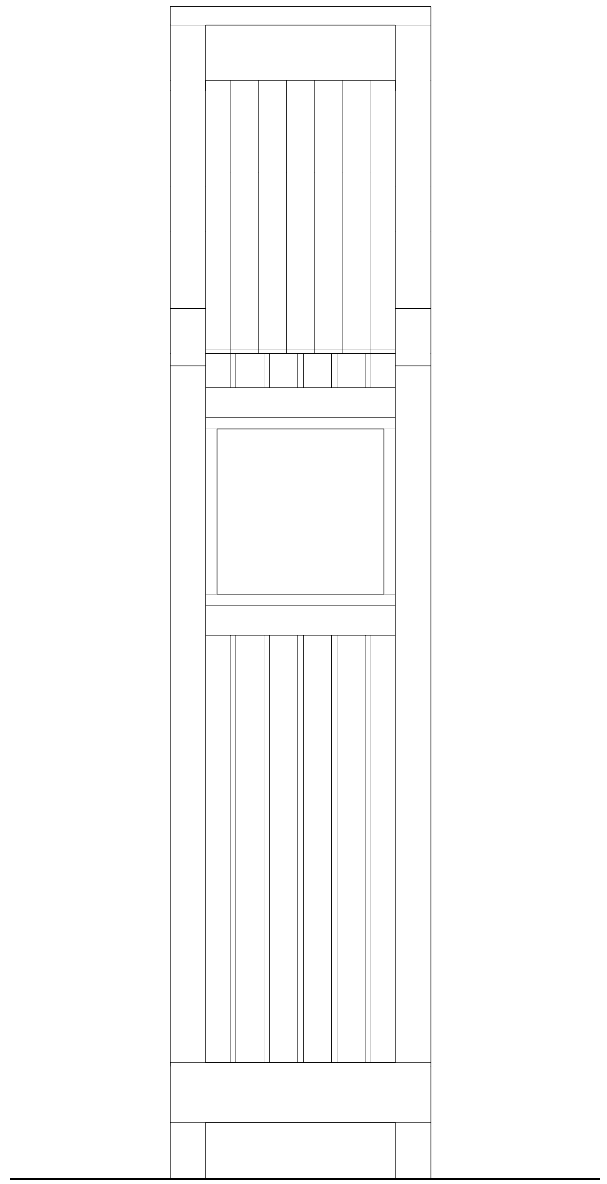
Generation 4
Wood

Generation 4
Wood

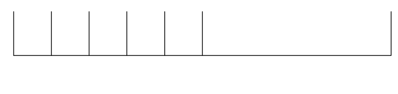
Plan 1:20



Section 1:20



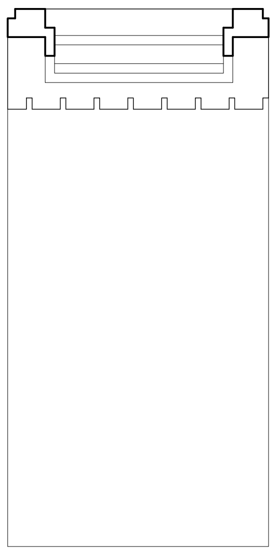
Elevation 1:20



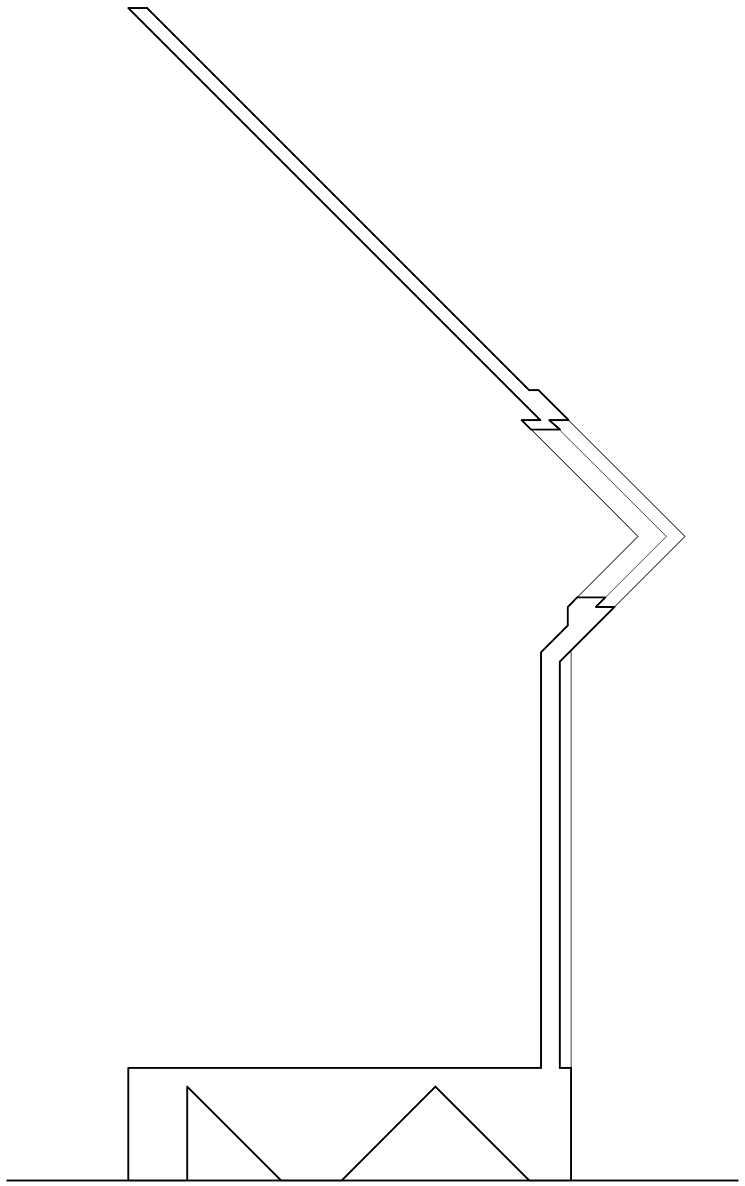
(A3)

Generation 4
Plastic

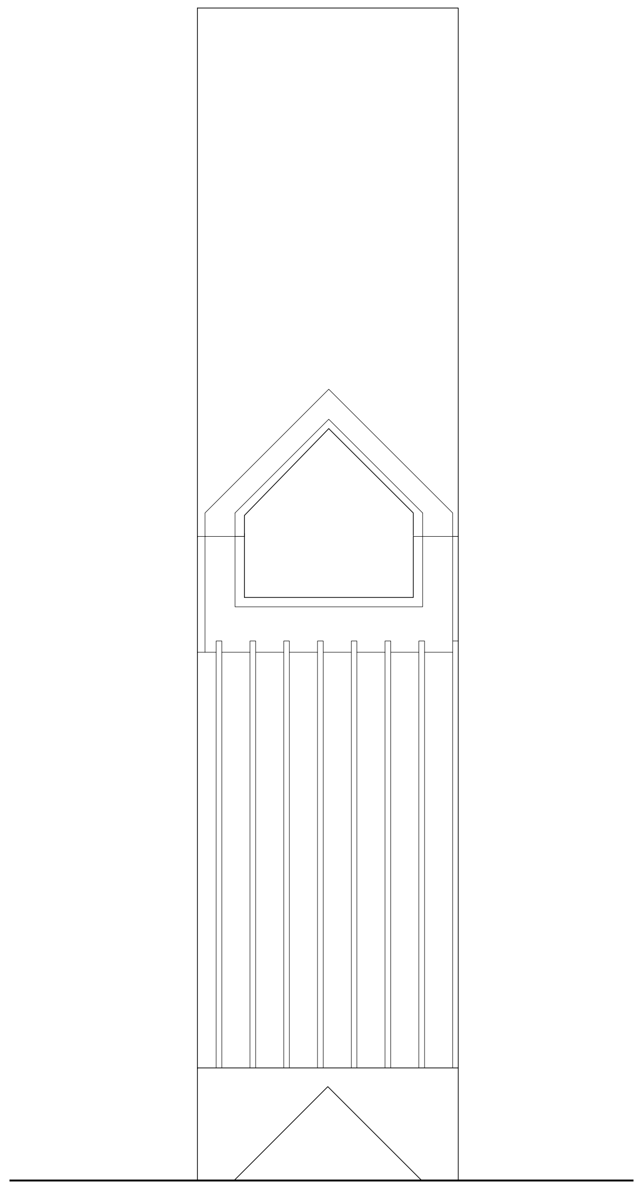
Generation 4
Plastic



Plan 1:20



Section 1:20



Elevation 1:20

(A3)

Generation 4
Summary/Findings

These last 2 iterations have explored how similar the different versions can be with these rules and a very rational approach. All materials have restrictions, which result in different quirks or challenges to achieve these features. It is also clear that some design features work very poorly in some materials, the frame around the window, for an example, is extremely difficult to achieve and even harder to make beautiful in rammed earth.

The 3d printed iteration in 1:20 was too thin and broke, so it is important to make it stable enough – something to develop i my next iteration.

The wooden version was therefore by far the most successful outcome.

Generation 5

Generation 6 has these features:

– Size: Length 3850 mm, width 2490 mm, height 2970 mm (by the ridge)

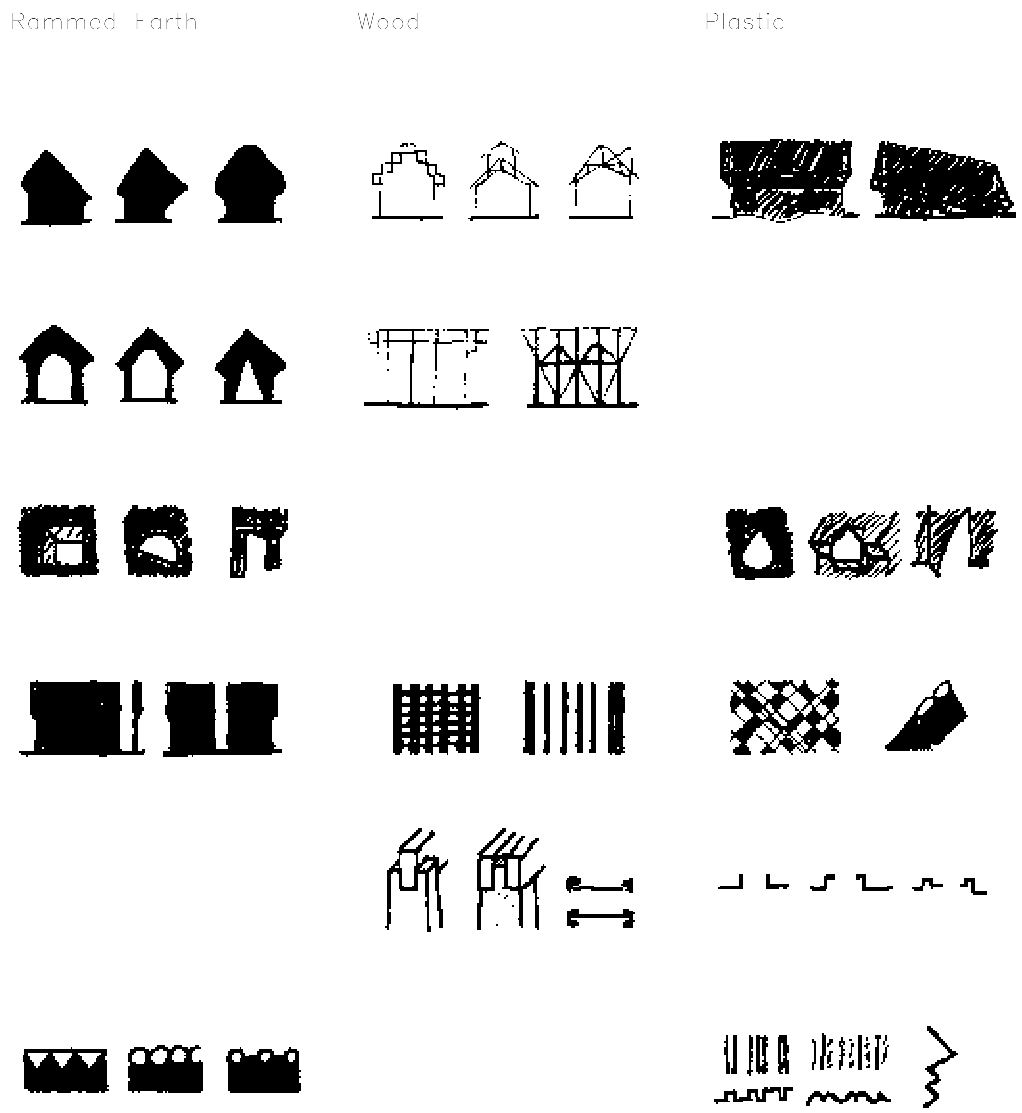
– Pitched roof

– Eaves around the whole building

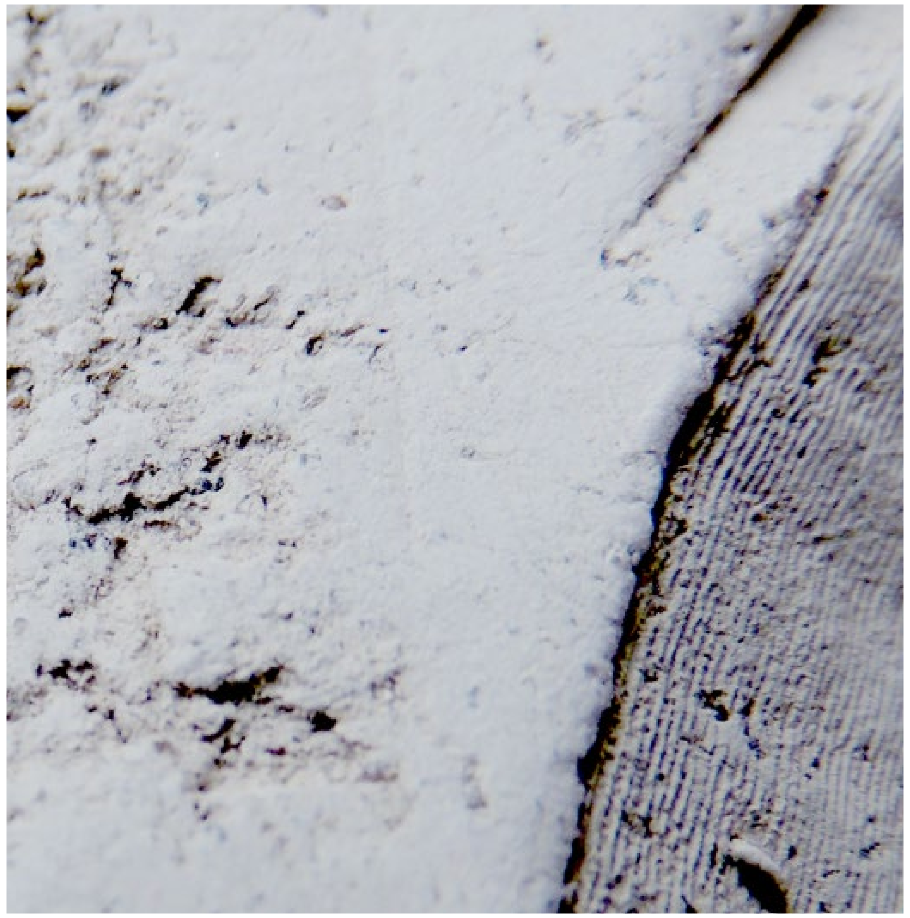
– Determined openings: Double door on one short end (1600x1850 mm), on one long end a single door (800x1850 mm) and a small window (500x500 mm) on a height of 1225 mm

– Plinth foundation

The diagrams beside shows parameters that are changeable that works in each material. These parameters regard outer shape, inner shape, openings, surface structure and meetings between components.

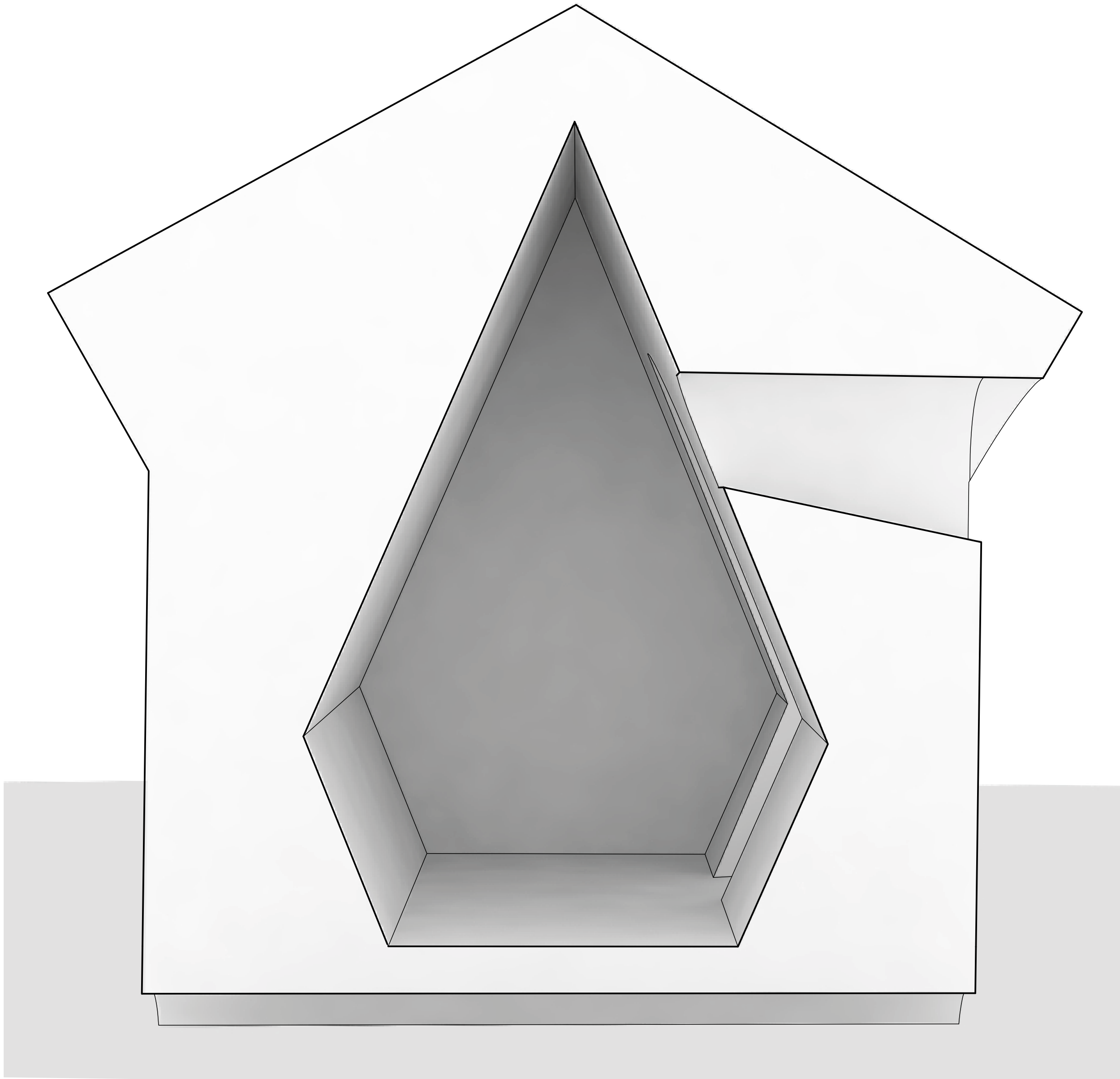


Generation 5
Rammed Earth



Generation 5
Rammed Earth

Generation 5
Rammed Earth

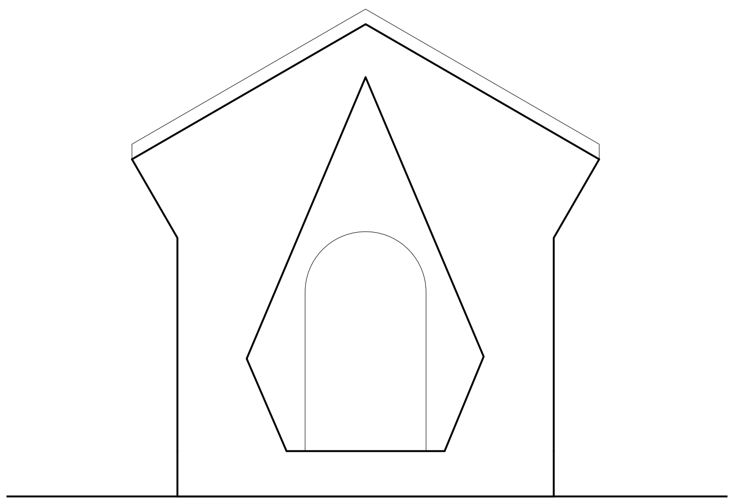


Section 1:20

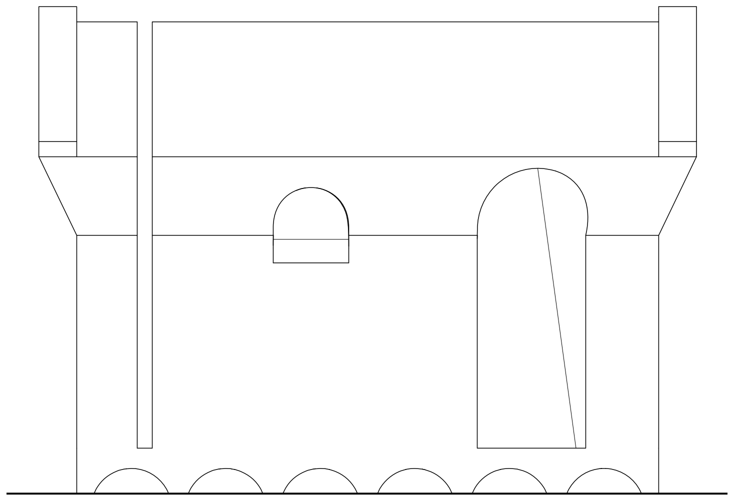
Perspective entrance

(A3)

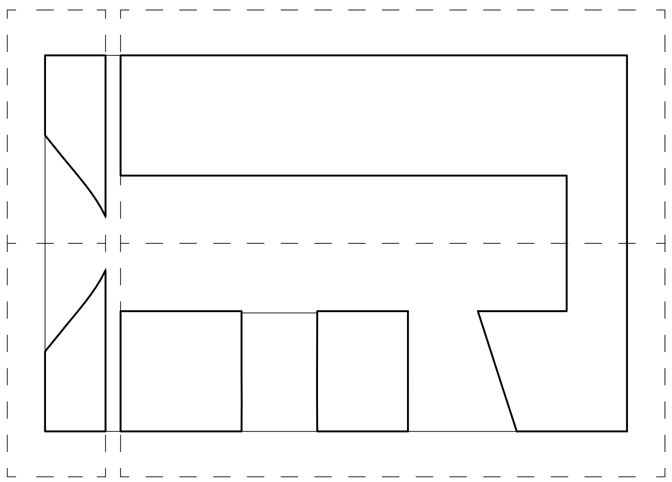
Generation 5
Rammed Earth



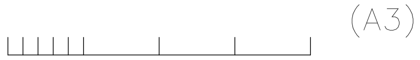
Section 1:50



Elevation 1:50



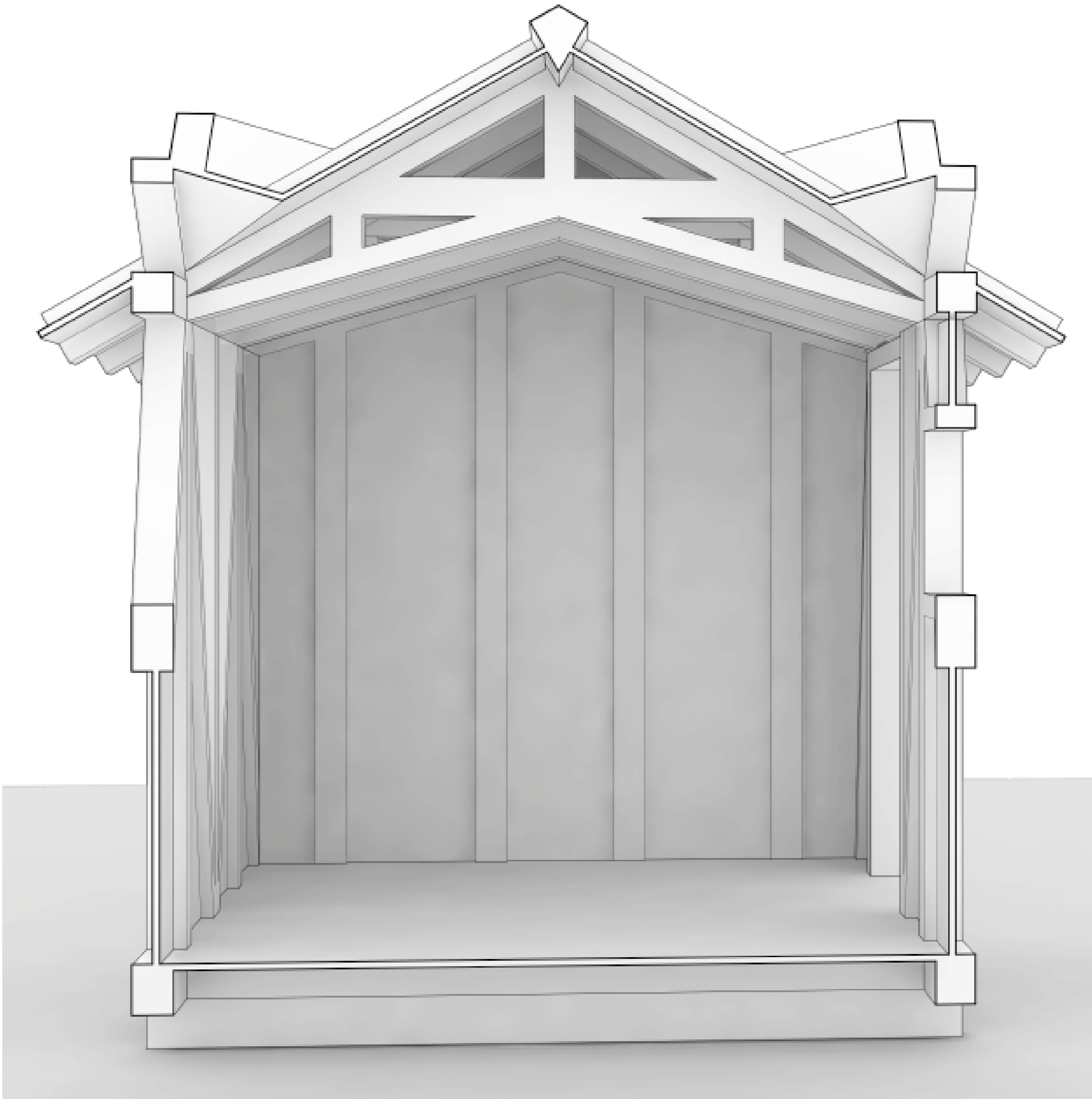
Plan 1:50



Generation 5
Wood

Generation 5
Wood

Generation 5
Wood

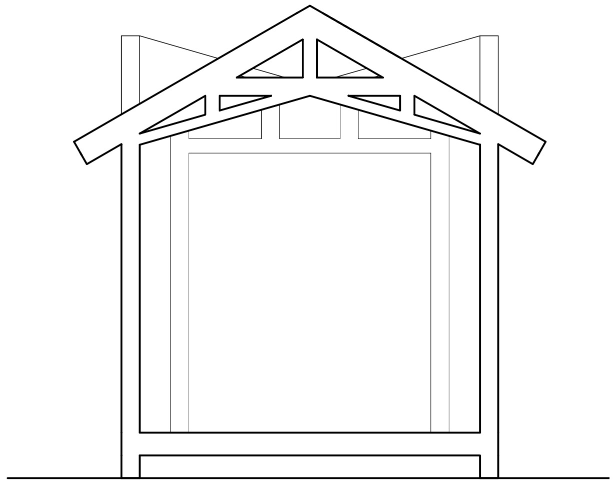


Section 1:20

Perspective entrance

(A3)

Generation 5
Wood



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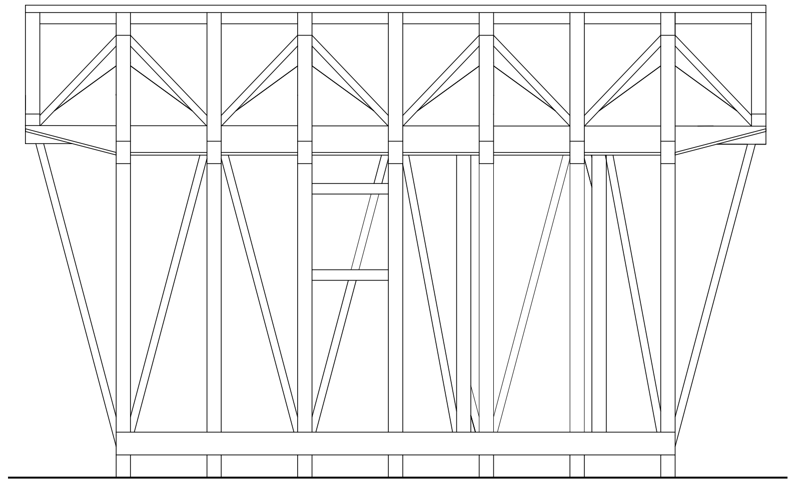

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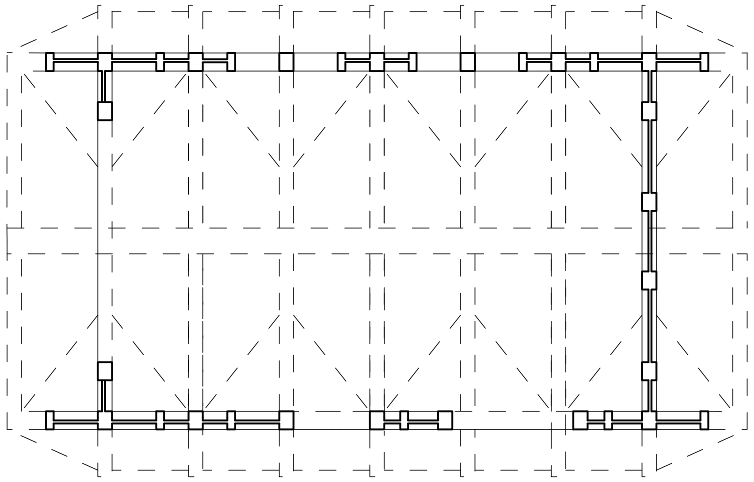


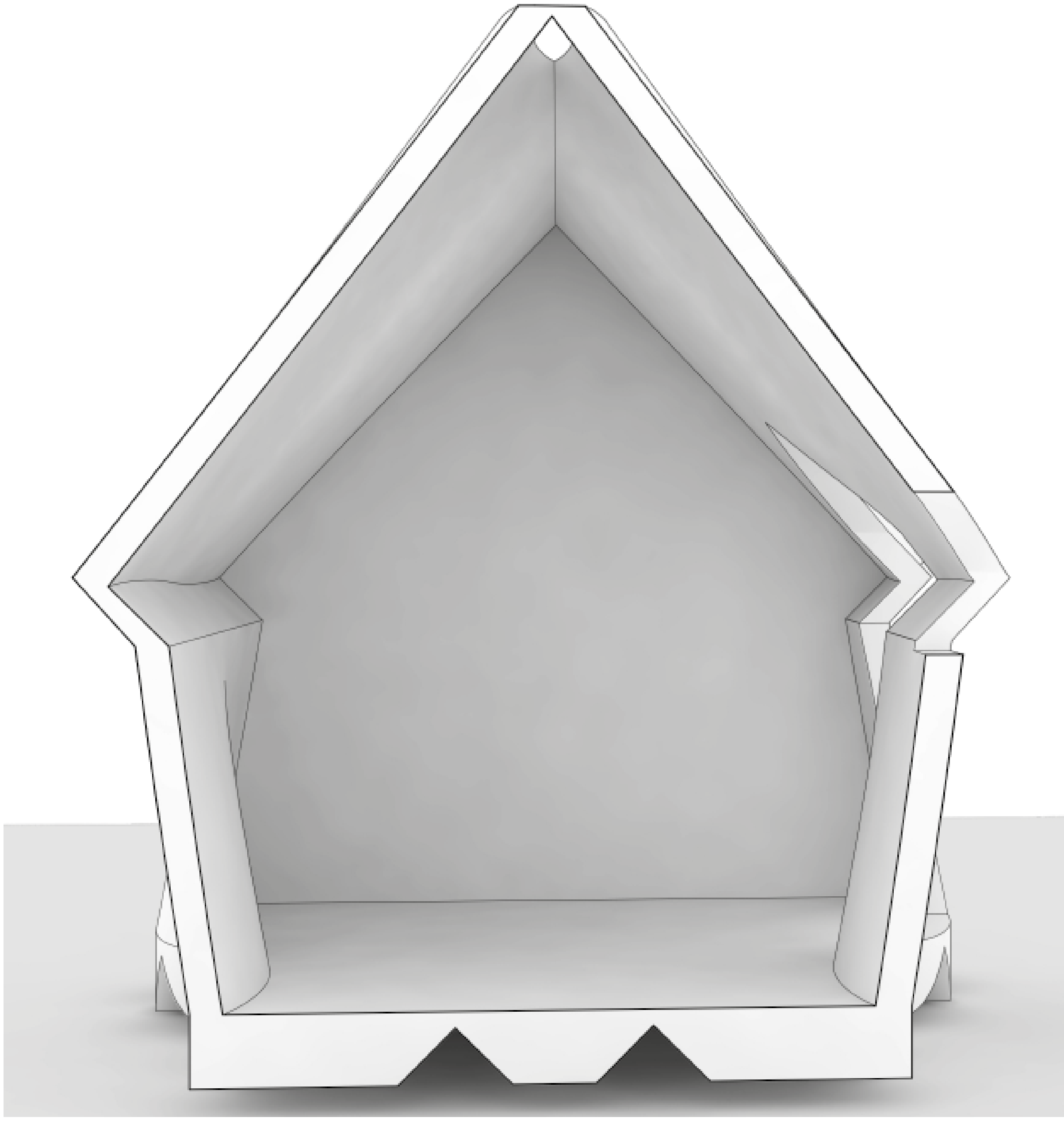
Plan 1:50

(A3)

Generation 5
Plastic

Generation 5
Plastic

Generation 5
Plastic



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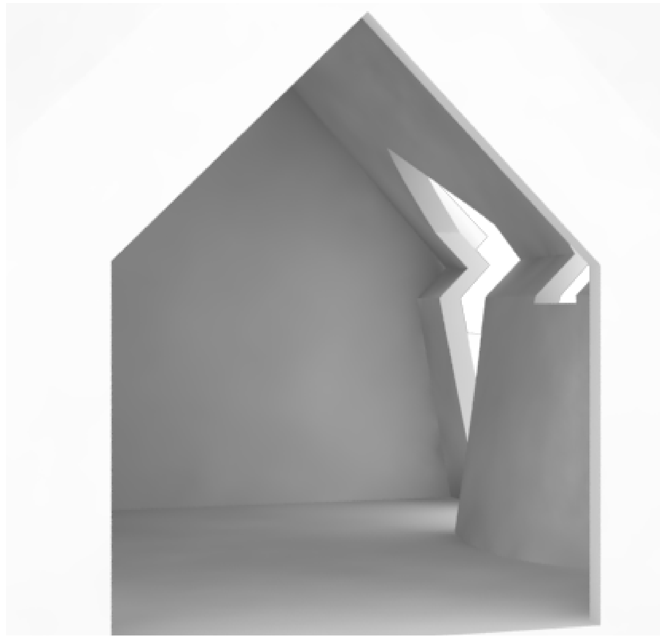

Perspective entrance

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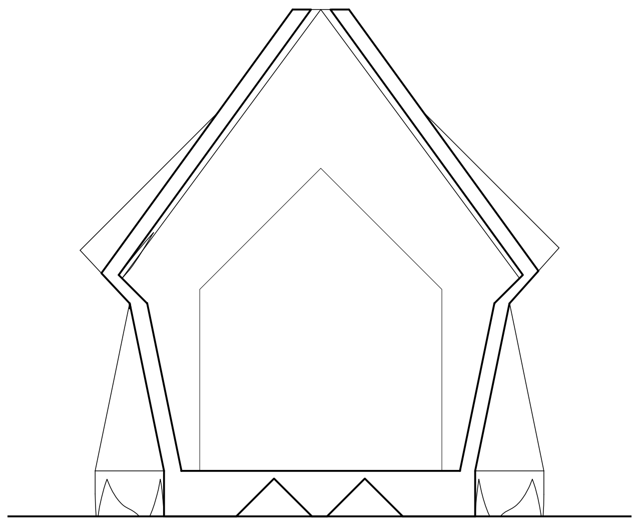

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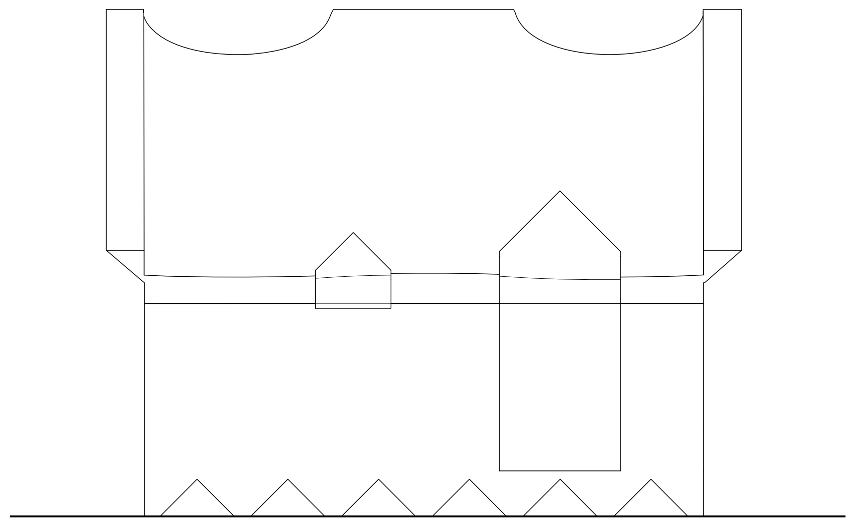

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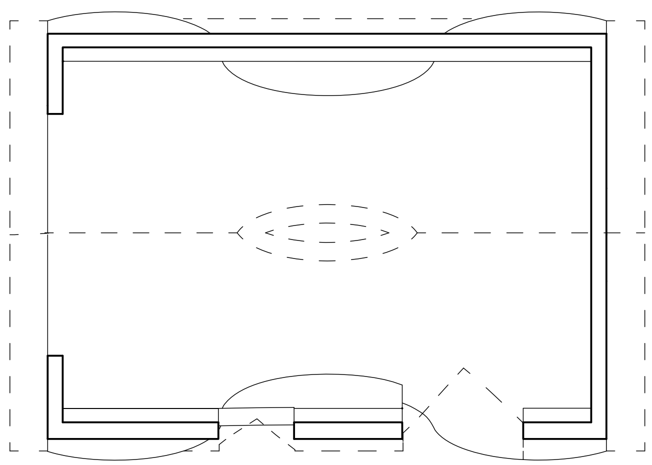


Plan 1:50

(A3)

Generation 5
Summary/Findings

Generation 6 was an attempt to tweak the design in ways suitable for the material and structure but still follow the features of the Friggebod. It was important for the investigation not to go too far away from the original design, so they still are recognizable. Next step for the different versions is to draw them further apart, maybe less recognizable, and to increase the detailed level by adding a program and build in furniture in the different materials.

In rammed earth, it is possible to change the inner shape in a few ways, this is one of them, that still enables the material to carry the load mostly in compression. It is, however clear that the arched shape works much better, it is stable and sets more inside space free. The corners are a challenge, so in one end the corners are simply taken away by cutting the walls before. This does not necessarily work optimal in this 1:20 iteration, because the walls are too thin, but according to all literature it should work in full scale. This also creates a nice light on the heavy wall. Since the walls are so thick, the openings have many possibilities to get different niches, which is also tried out. This also makes it easier to remove the molds from the rammed earth.

The wood structure with its vector-active structure has a pretty obvious addition in dormer windows, which is a way to get more sticks in. This is a way to really investigate how many sticks a model can have. Since the surfaces in between the sticks do not have any structural properties, the structure get diagonal sticks to keep the structure steady. They also hold up the elongated eaves on the short end, The structure is also opened up between the sticks in some places, which is a good way to get in more light.

The plastic is in some ways free in the shape (not when it comes to cantilevering, of course), and since it should be pretty thin, a good way to manipulate the design is to give the surface some curvation, which stabilize the structure and gives it a freed form. This is done both on the walls and the roof, which changes both the outer and inner shape and gives the plastic version a very specific and sort of humourous design. This also gives the roof an opening in the middle, which brings in light.

Generation 6
Hybrid

The next challenge in the process is to try to put all materials together into one hybrid version. The challenge here is to go beyond the obviuos ways to use the materials (they should be not only in the most suitable places but also in unexpected places) and to make the materials meet in suitable and beautiful ways.

The first version is a practice of many ways to use the materials and put them together, so the design is a bit overloaded, but there is a point to that. The next steps for this version should be, as for the other versions, to go more into detail in program and put in furniture etc, and after that to look closer into how the materials are assembled and joined together. How do you join wood and plastic in the best way?

Figure 30. Portuguese Pavilion, Siza. (JoshEwwAhh, 2006)

Figure 31. Fischer House, Kahnd. (Mudford, 1967)

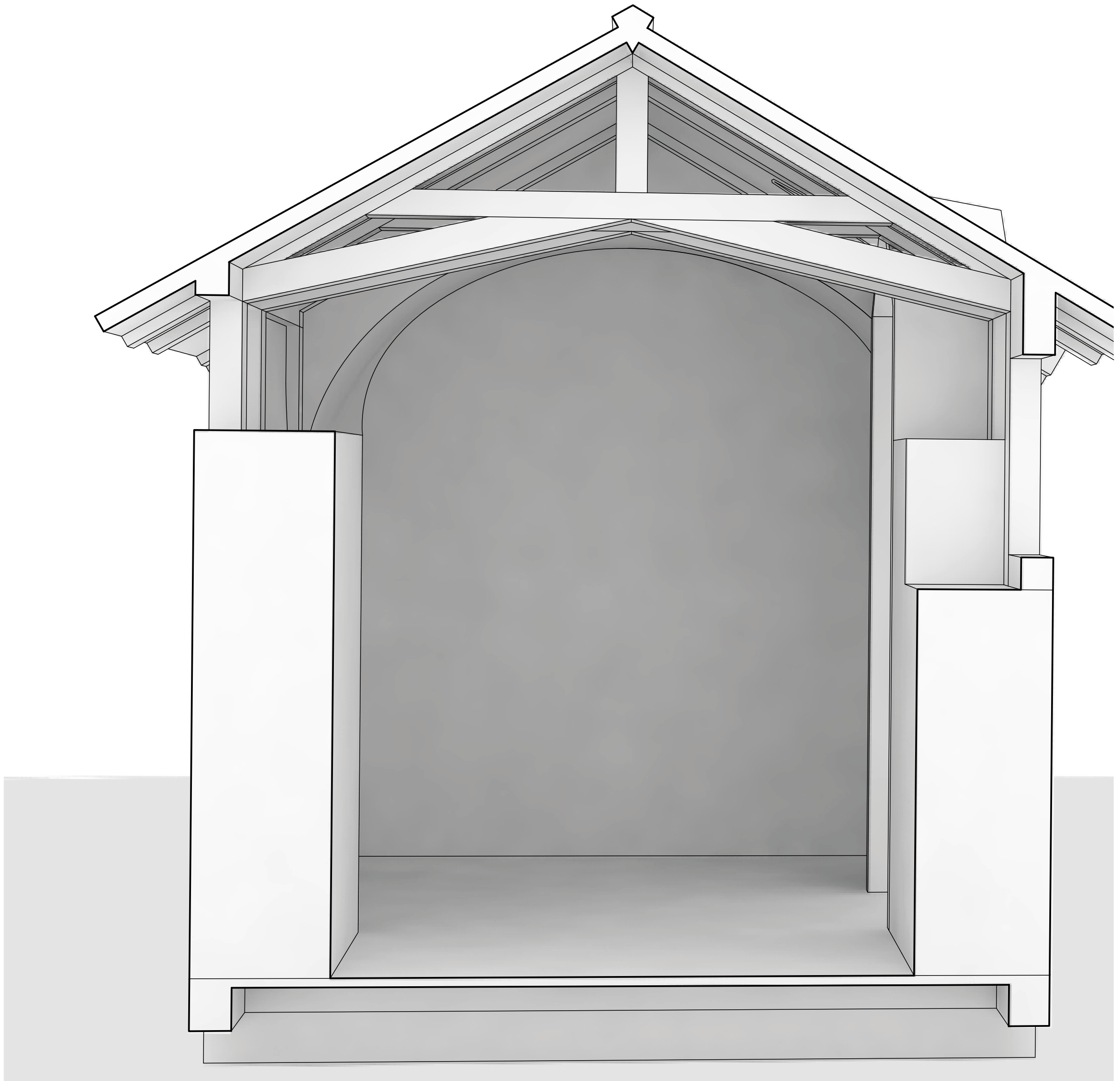
Figure 32. Hedmarks Museum, Fehn. (Author's own image)

Figure 33. Neues Museum, Chipperfield. (Weyer, 2011)

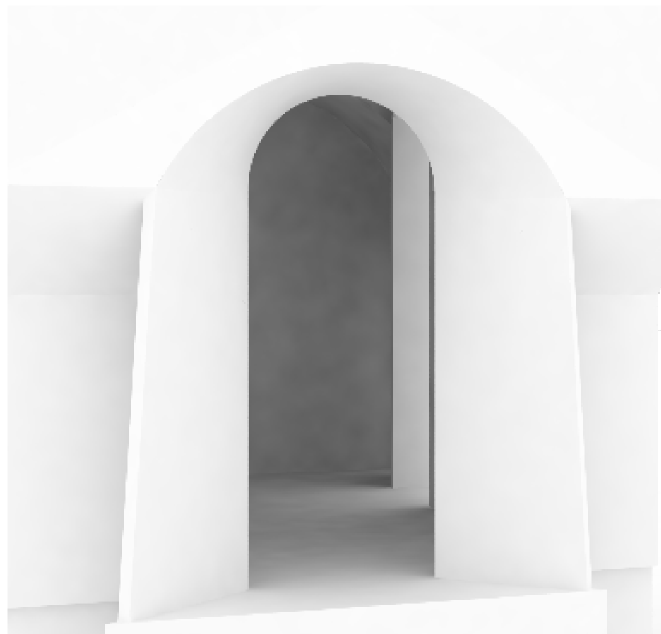
Generation 6
Hybrid

Generation 6
Hybrid

Generation 6
Hybrid

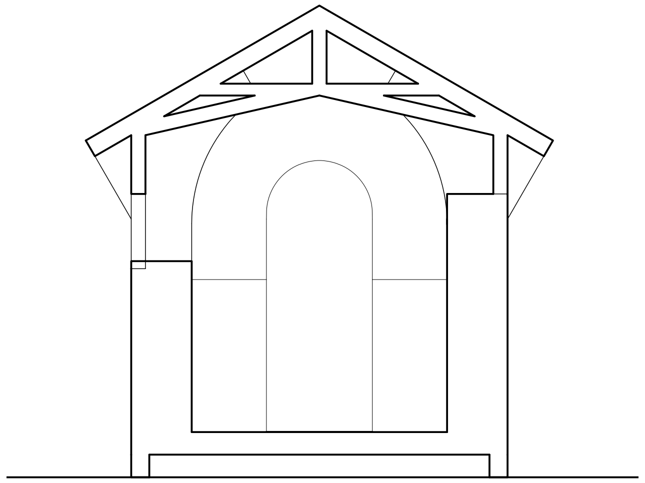


Section 1:20



Perspective entrance

Generation 6
Hybrid



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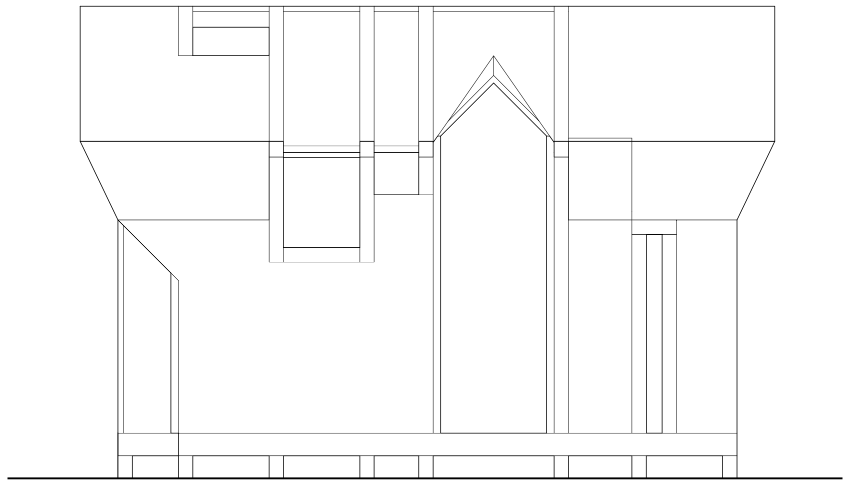
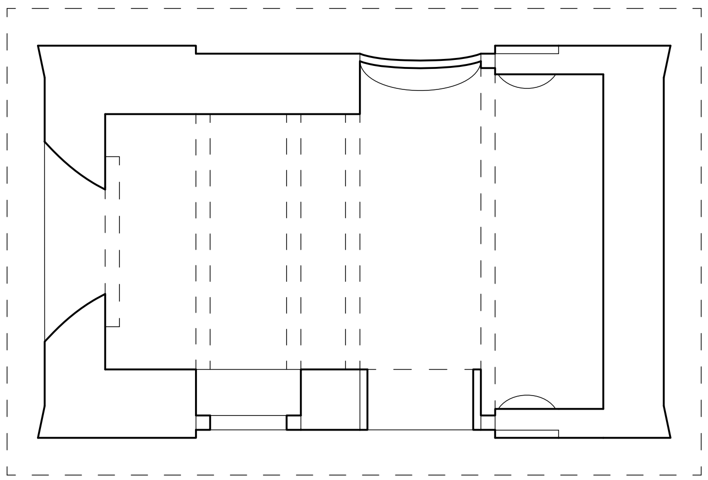


Elevation 1:50



Plan 1:50

(A3)

Generation 6
Hybrid Summary/Findings

It was a pretty big challenge to design the hybrid model. Combining two materials (and techniques) is much easier, when a third one comes in everything is more complicated.

I tried to combine the materials in different elements, as in the big entrance, where the rammed earth rests on the plastic and takes over in the middle of the opening. The paradox in the heavy rammed earth resting on the thin plastic was another important thing in the study, to let materials be used in unexpected not always optimal ways. The design should be more about showing how the materials are different than to use them where they would work best in the "real" world. This is a theoretical project, having for example a roof in rammed earth would not work very well in the Swedish weather, but there is a point in showing what that would be and how it would work combined with a wooden roof.

What I found lacking in this iteration was the tectonic aspect of how the materials meet. Here, the materials are put on each other in a way resembling a collage, but there are better ways to make them lock into each other, for example by using the plastic and wood as molds for the rammed earth. This is what I want to explore in the next, final iteration, as well as putting in furniture to get the Friggebod a program and purpose, not only being an empty shell.

Generation 7
Final Design

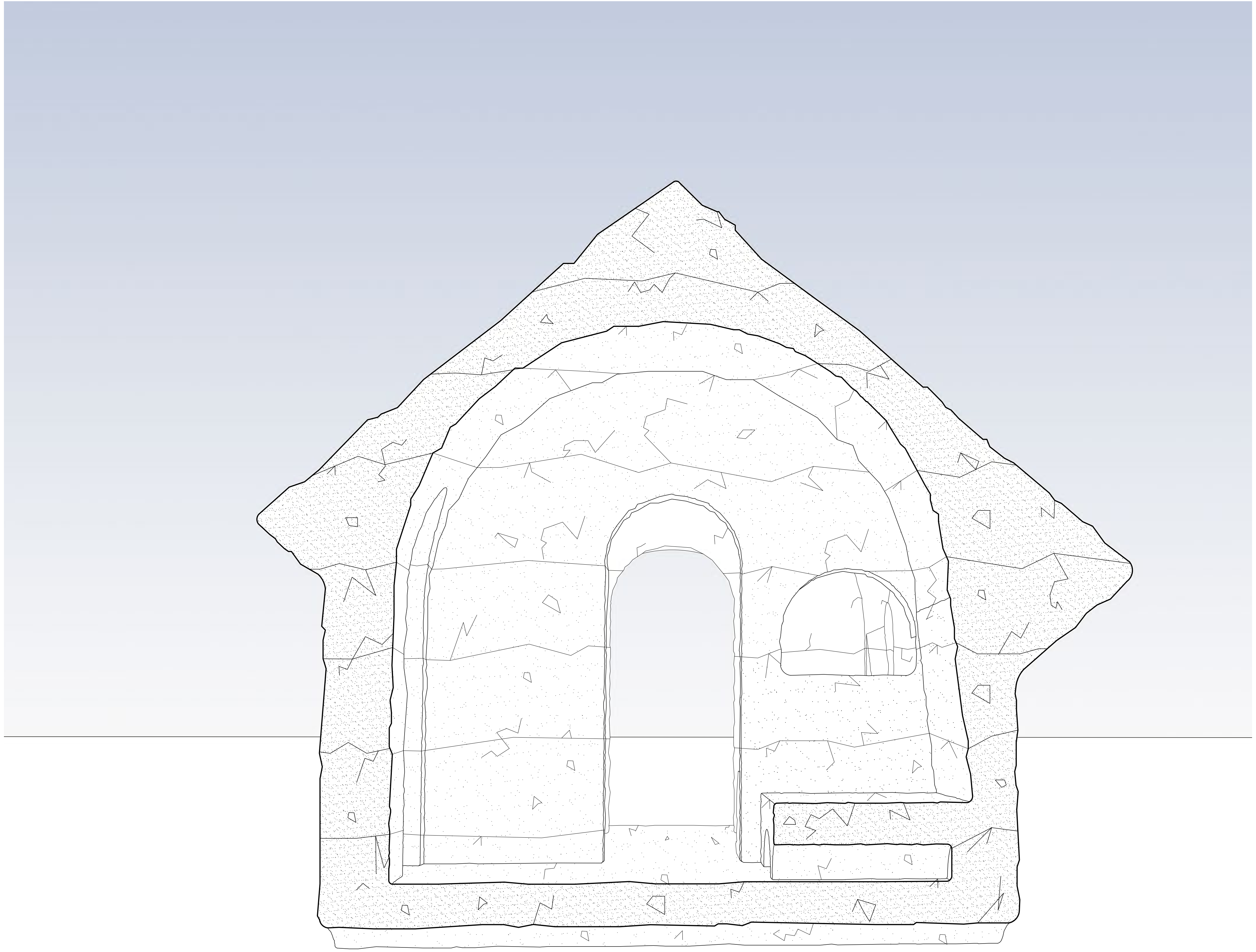
The last iteration, in both the separate materials and the hybrid, got a kitchen, dining area and bed, to give it a program of a small overnight cabin. The separate versions got more of the earlier design work, such as textures, patterned openings etc.

The rammed earth version got patterned textures with help of circular molds, angled niches in different directions and furniture that have the feeling of being "carved out" of the material. The exploded assembly axo shows how the formwork is built up to pour the earth into, this is however done in sections and not everything at once. This shows how difficult it is to build complicated shapes in rammed earth.

The wood version got the stacked "kaplastavar" as an extra light source and bigger dormer windows. The furniture is added, but as a part of the structure and determination of openings. The exploded assembly axo shows that the wooden pieces are added and joined together.

The plastic version got more patterned textures and openings, to really show how free the plastic is, in these kinds of ways. The furniture is a part of the layer of the overall structure, as can be seen in the exploded assembly axo where everything is built up at the same time, by adding more and more layers.

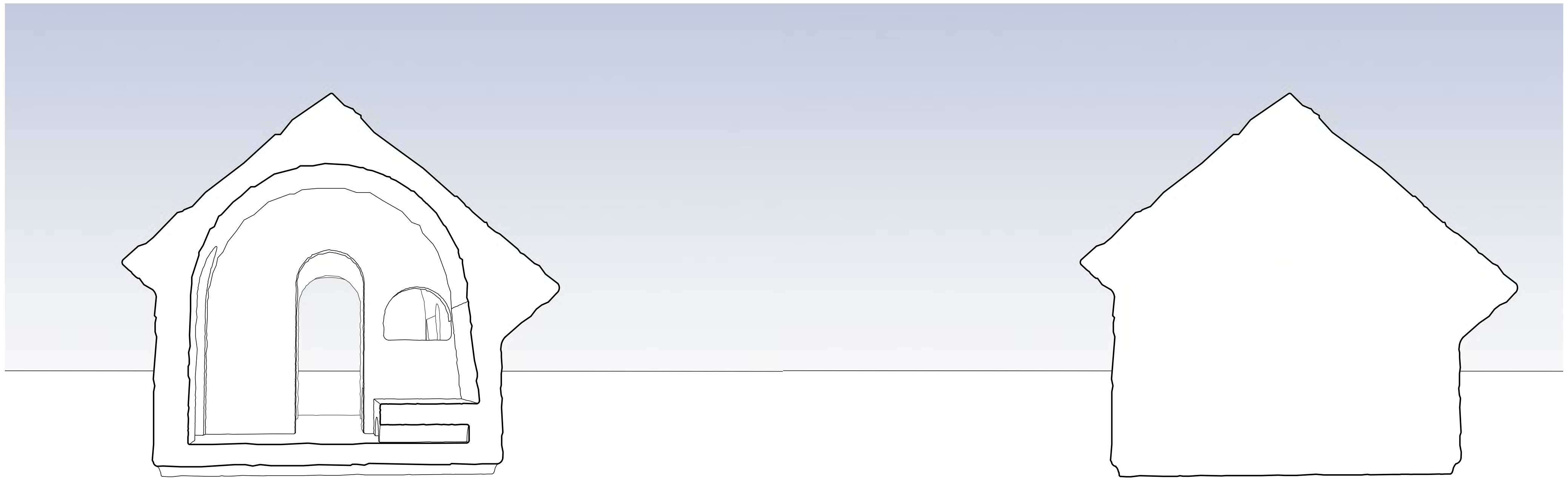
Generation 7
Rammed Earth



3d Section of Rammed Earth
1:20

(A3)

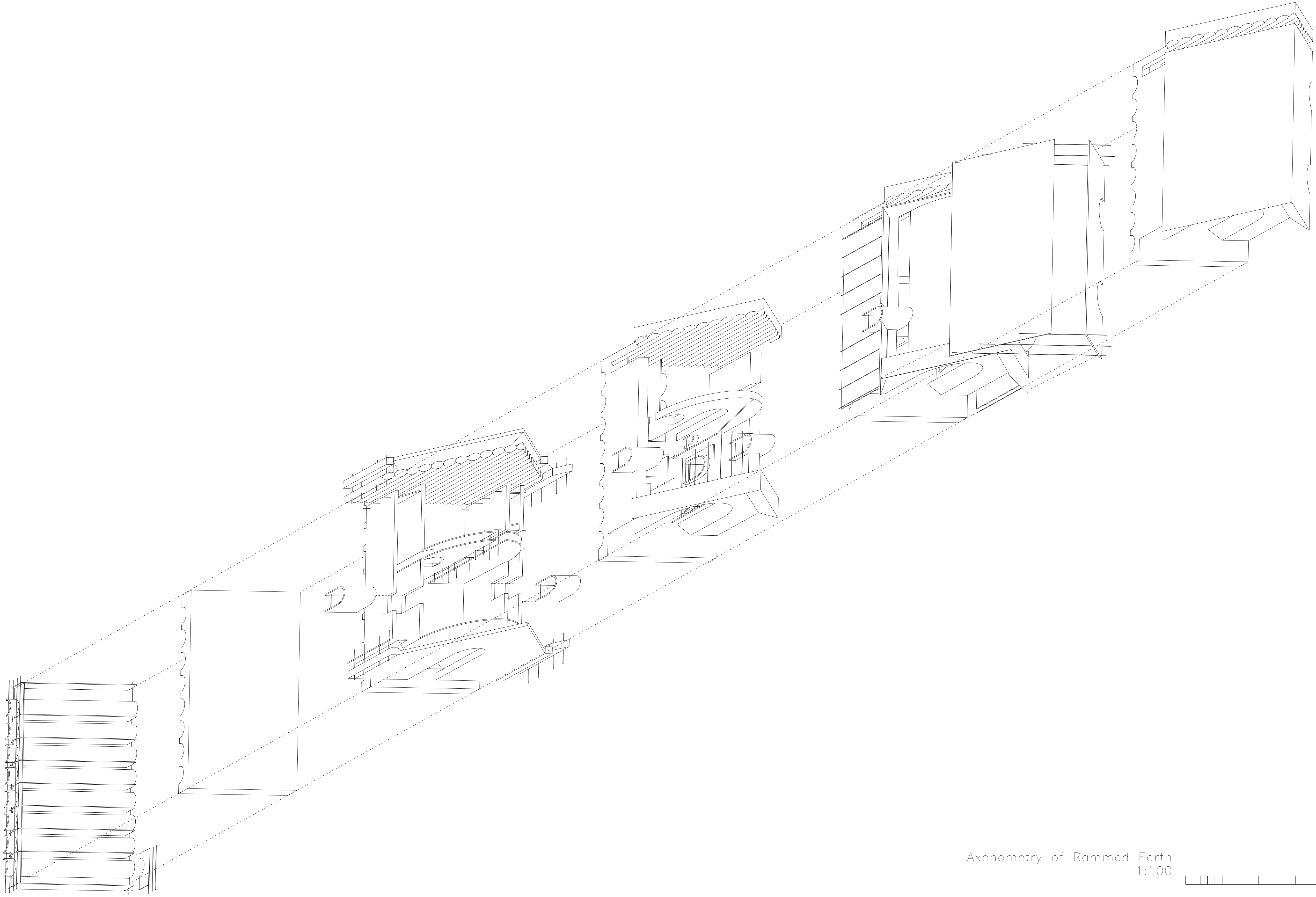
Generation 7
Rammed Earth



Diagrams of Rammed Earth
1:50

(A3)

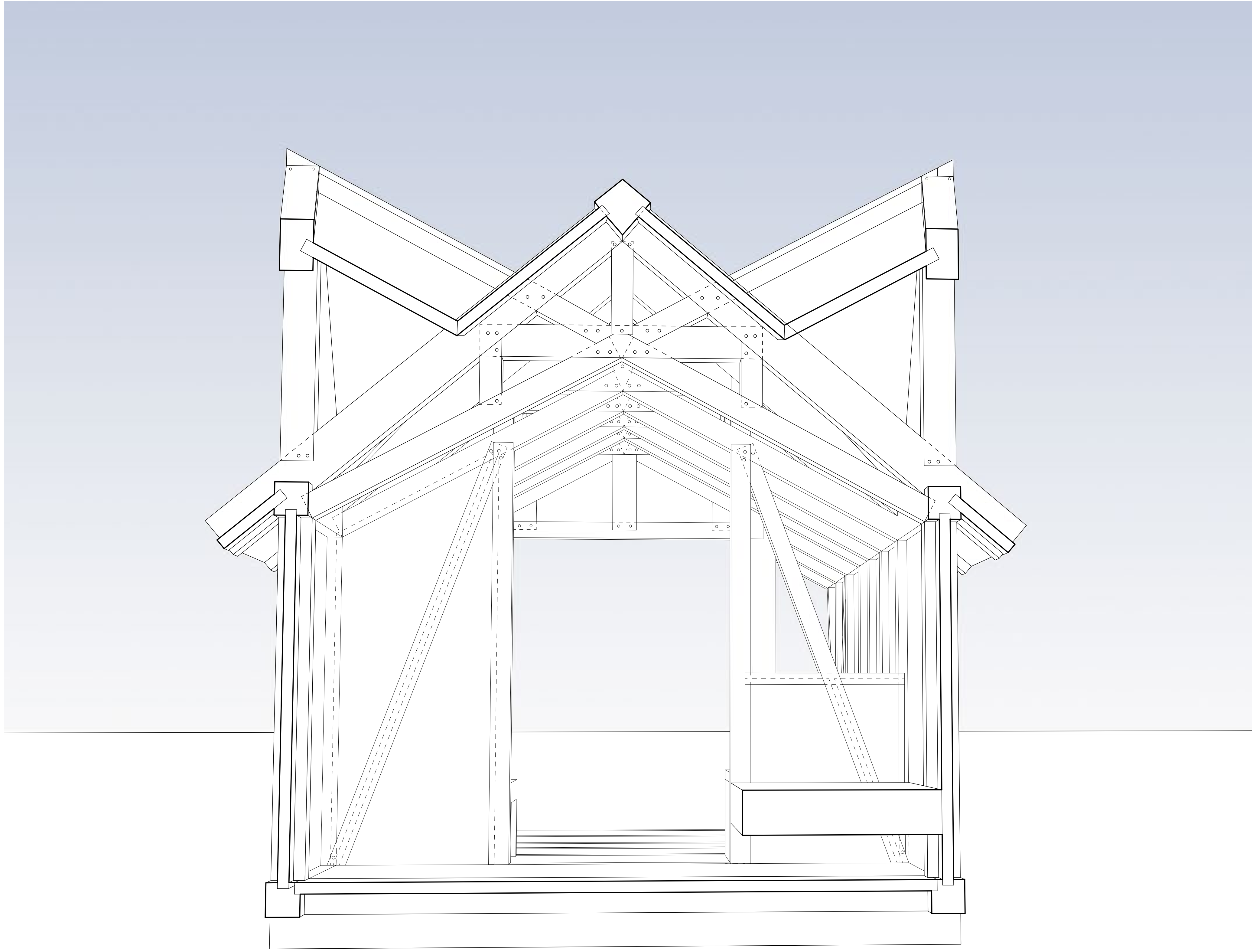
Generation 7
Rammed Earth



Axonometry of Rammed Earth
1:100

(A3)

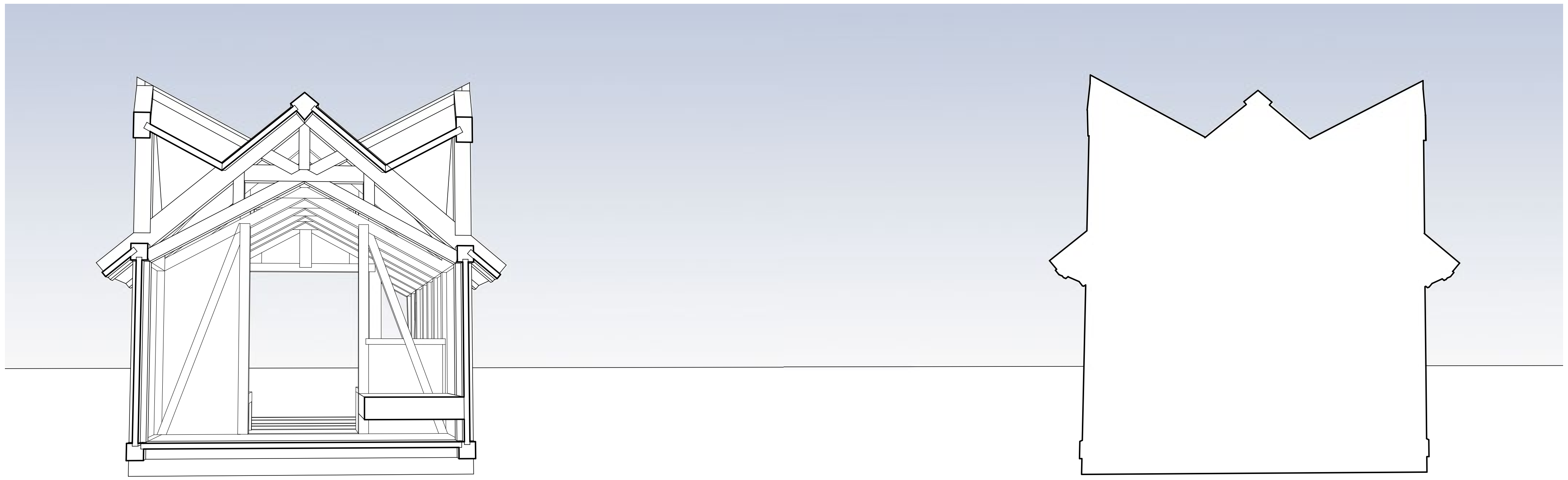
Generation 7
Wood



3d Section of Wood
1:20

(A3)

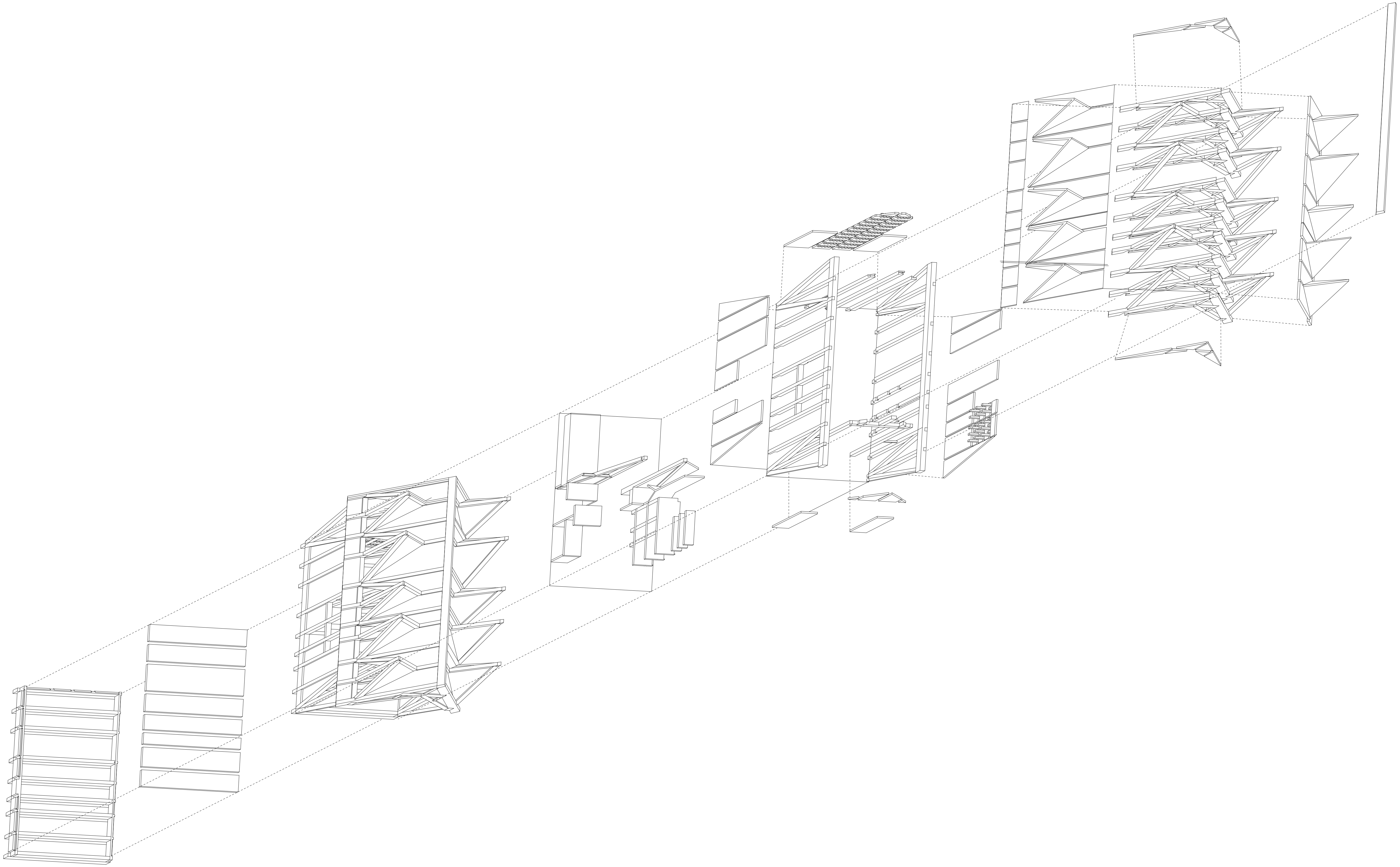
Generation 7
Wood



Diagrams of Wood
1:50

(A3)

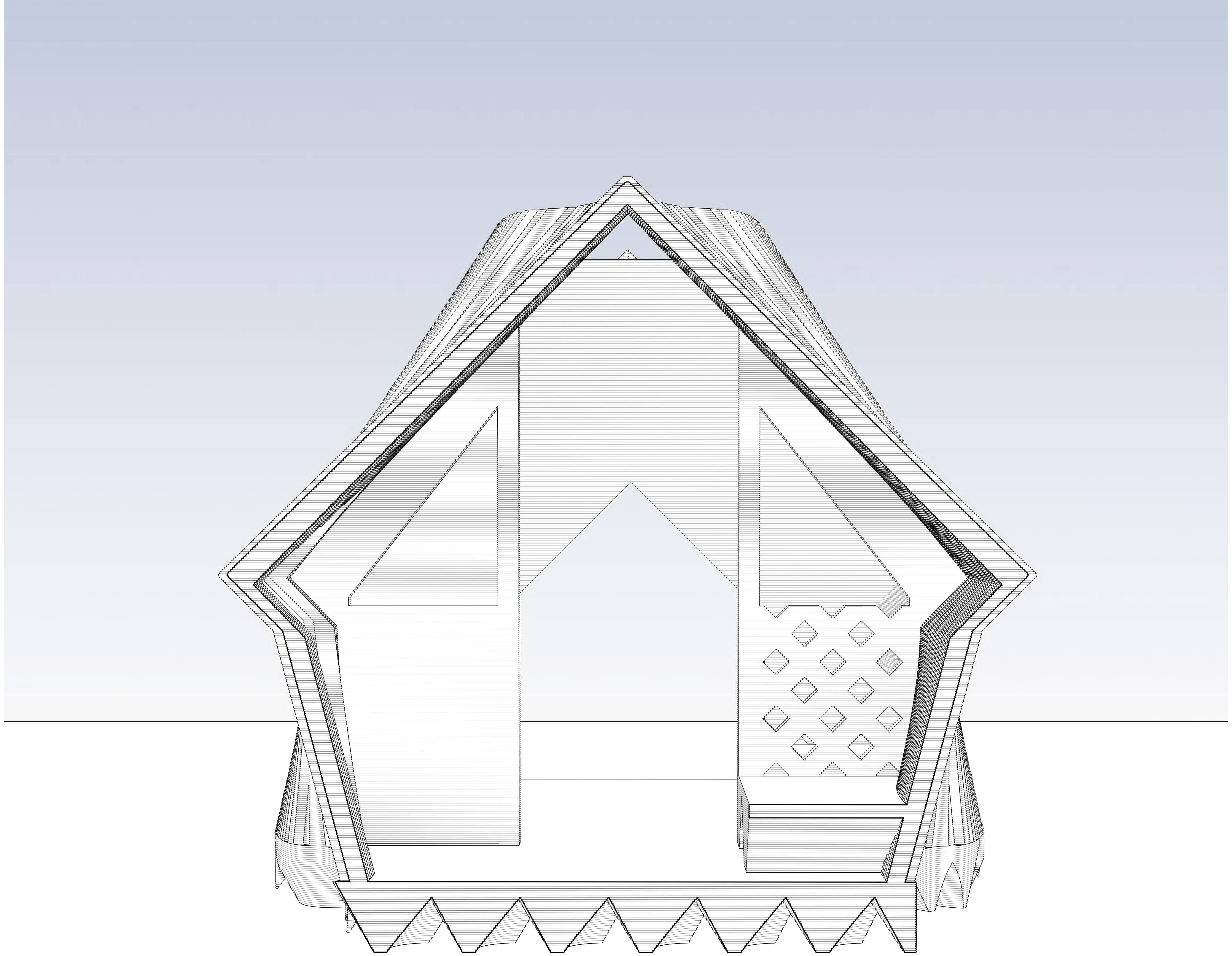
Generation 7
Wood



Axonometry of Wood
1:100

(A3)

Generation 7
Plastic



3d Section of Plastic
1:20

(A3)

Generation 7
Plastic

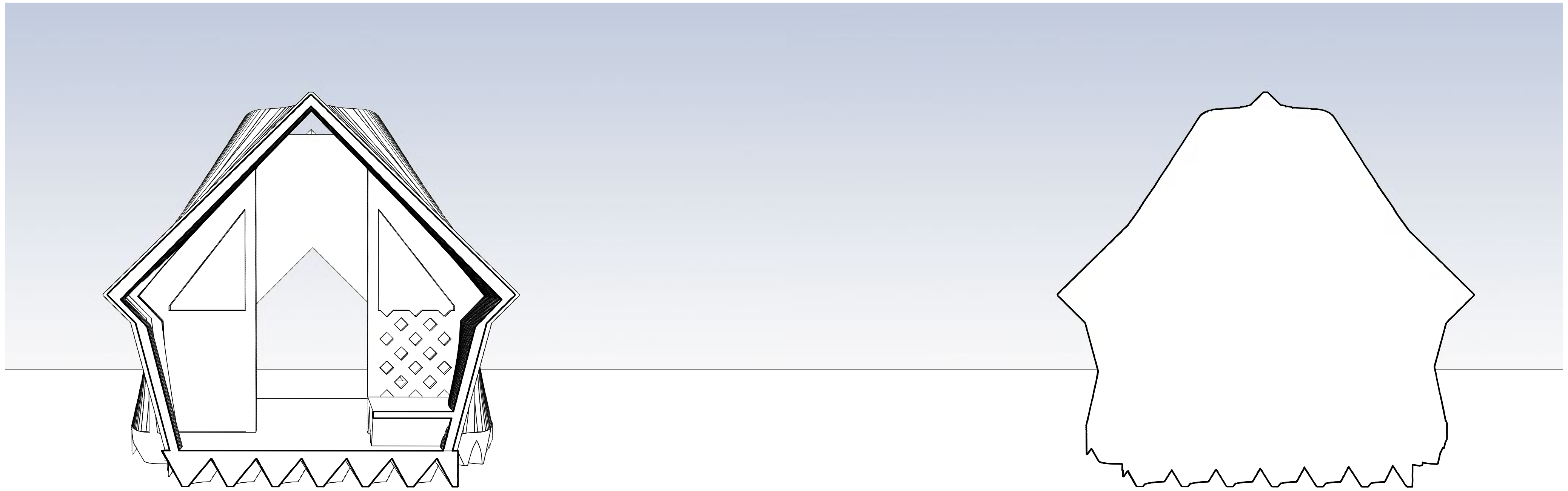
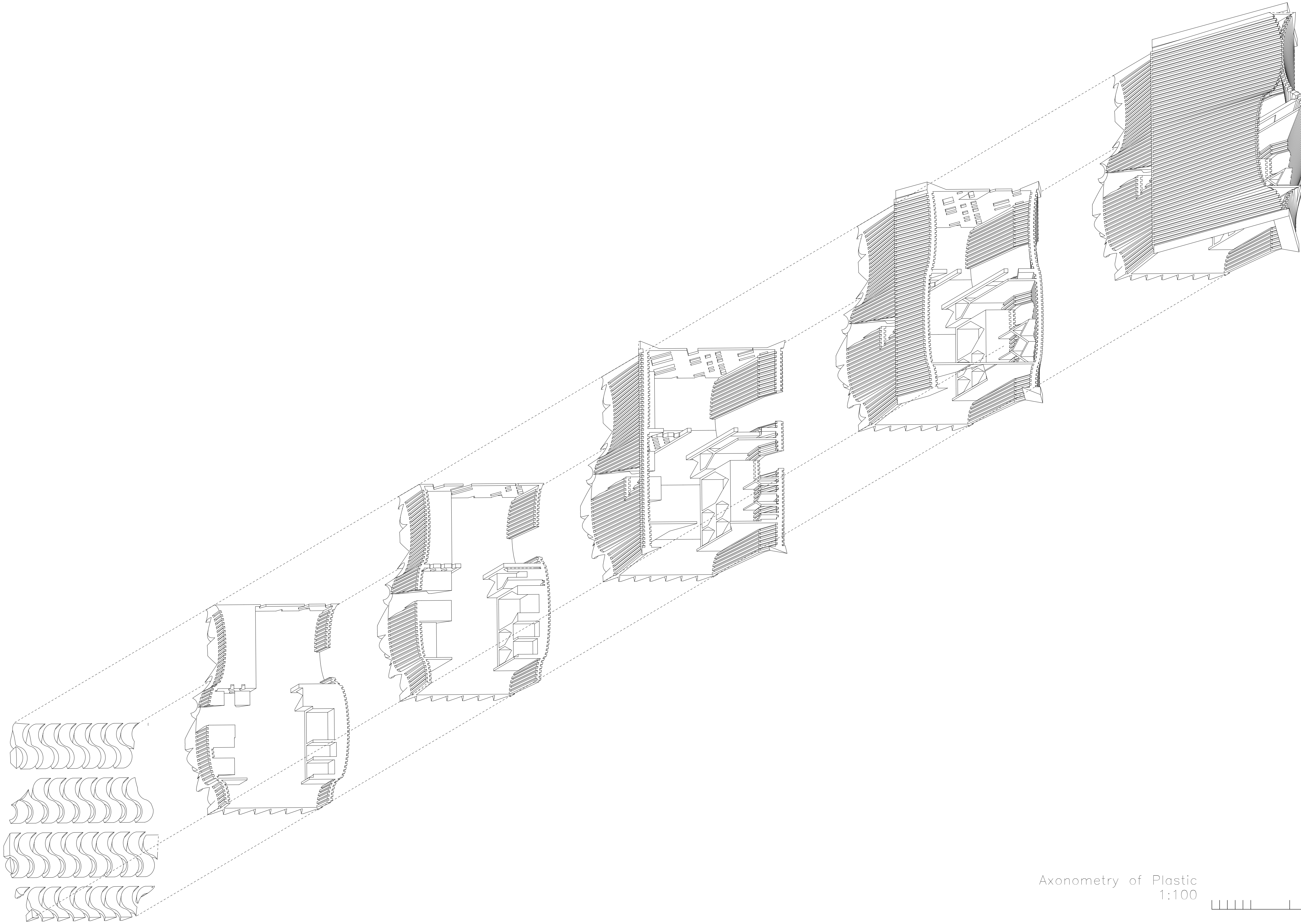


Diagram of Plastic
1:50

(A3)

Generation 7
Plastic



Axonometry of Plastic
1:100

(A3)

Generation 8
Final Design Hybrid

The hybrid is a combination where the materials are put together in a way which hopefully shows the pecularities and differences of all the materials. It is not designed to be optimal or work in an outdoors climate. In that case, the building would have a plastic roof covering everything, to protect from rain, and simple rammed earth walls, to hold it up, stabilize and give weight to the construction, with a wooden floor. This would not be as big a challenge.

The wood and plastic often works as molds for the rammed earth, to be left in the structure afterwards. This proved to be difficult since the rammed earth shrunk when drying, so some improvements had to be made afterwards.
To build the model was a way of discovering the problems with the different materials. The plastic is very unflexible, so if there is a problem with any other material, the plastic is still fixed and unchangeable. The rammed earth is not very precise and when comining it with the other materials it is not easy to keep it straight.

There is a particular order of how everything should be put together and produced for it to work, which is partly shown in the exploded axo. The furniture in this version where the easiest to design, since they are able to use the materials in optimal ways.

The result is, according to me humorous at the outside and pretty atmospheric on the inside. When thinking of ”essence” and ”materials”, this is not what I would have thought of but in many ways, responds to these notions, in an unexpected way.

Generation 8
Final Design Hybrid

Generation 8
Final Design Hybrid

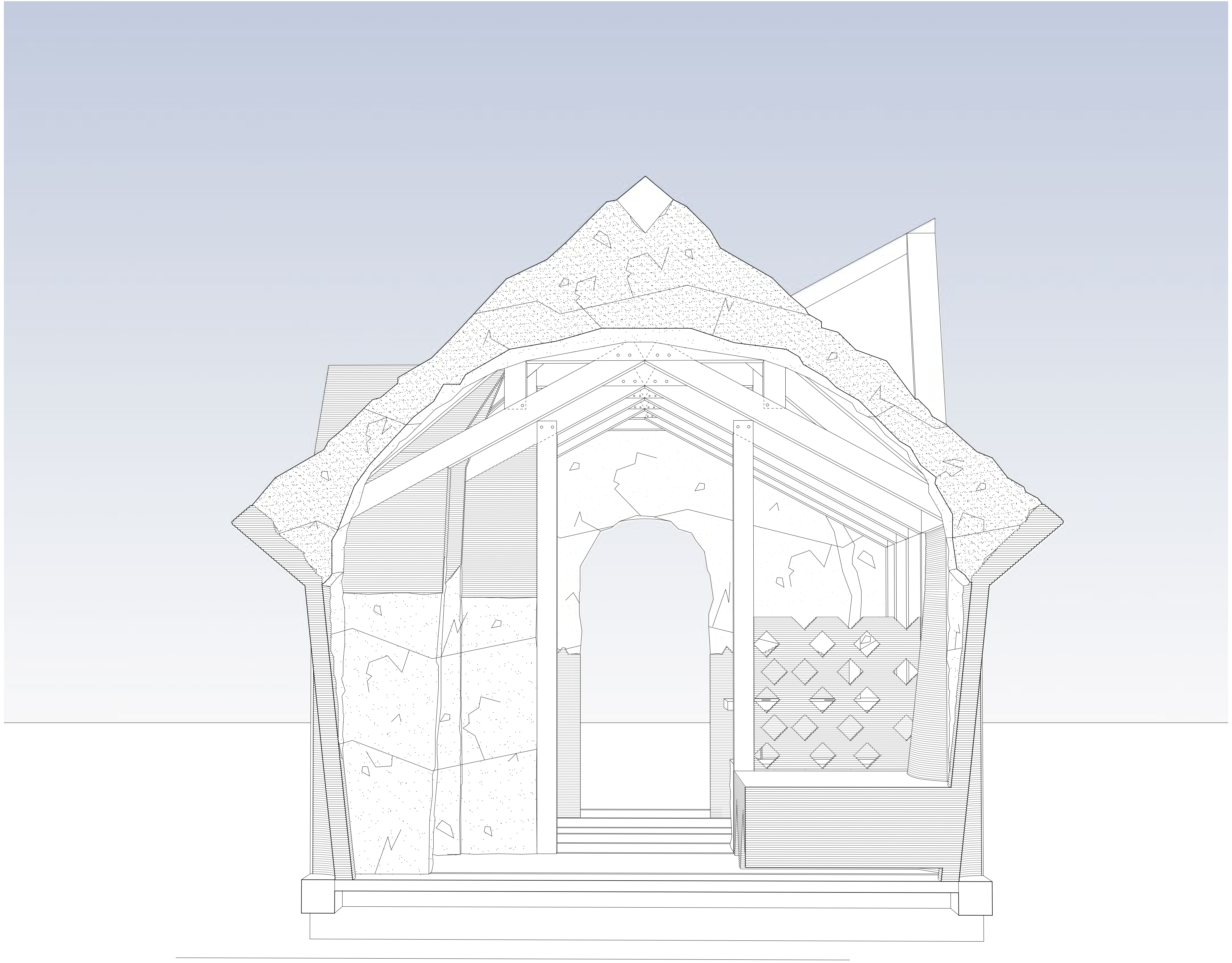
Generation 8
Final Design Hybrid

Generation 8
Final Design Hybrid

Generation 8
Final Design Hybrid

Generation 8
Final Design Hybrid

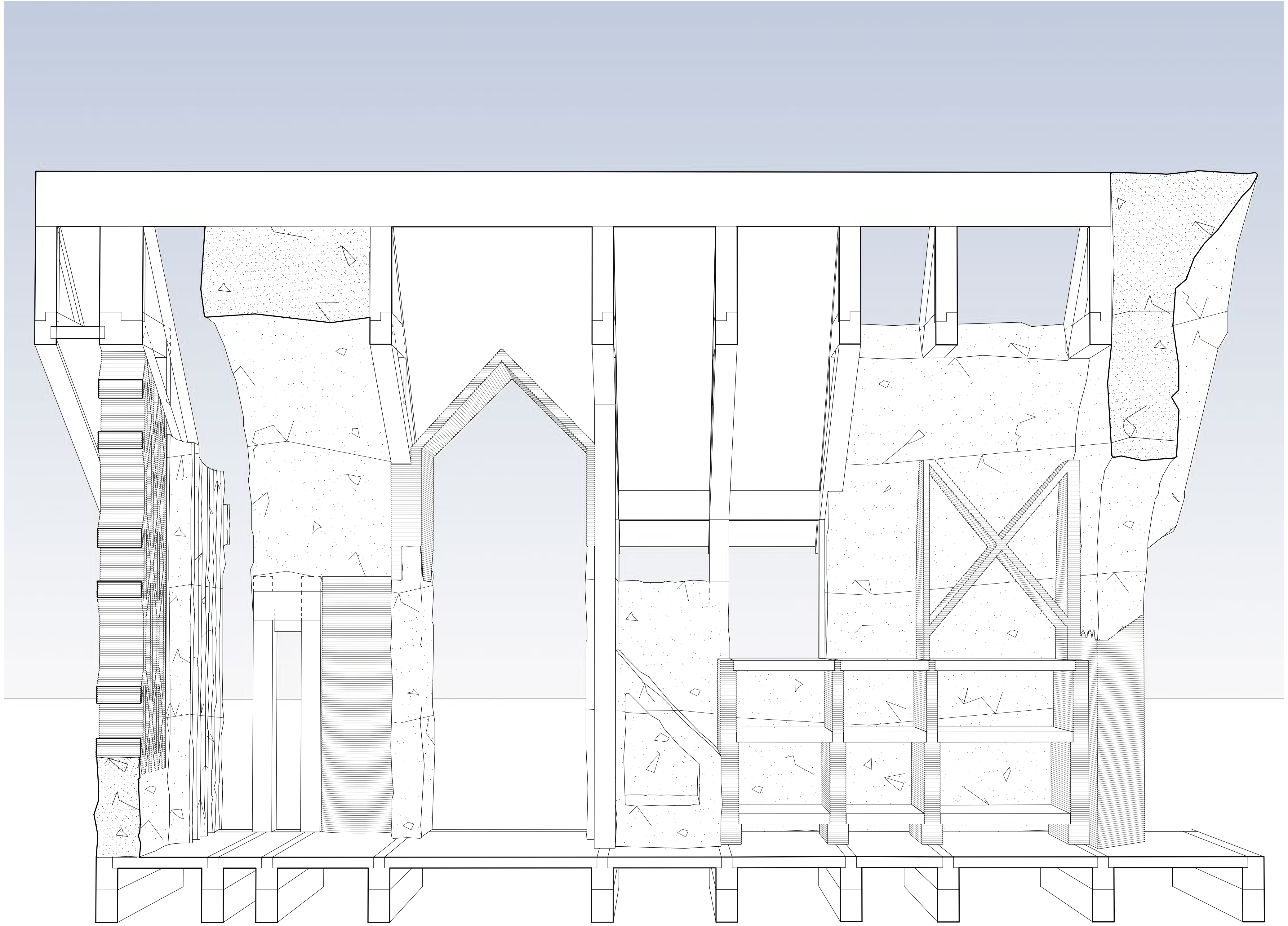
Generation 8
Final Design Hybrid



3d Section Hybrid
1:20

(A3)

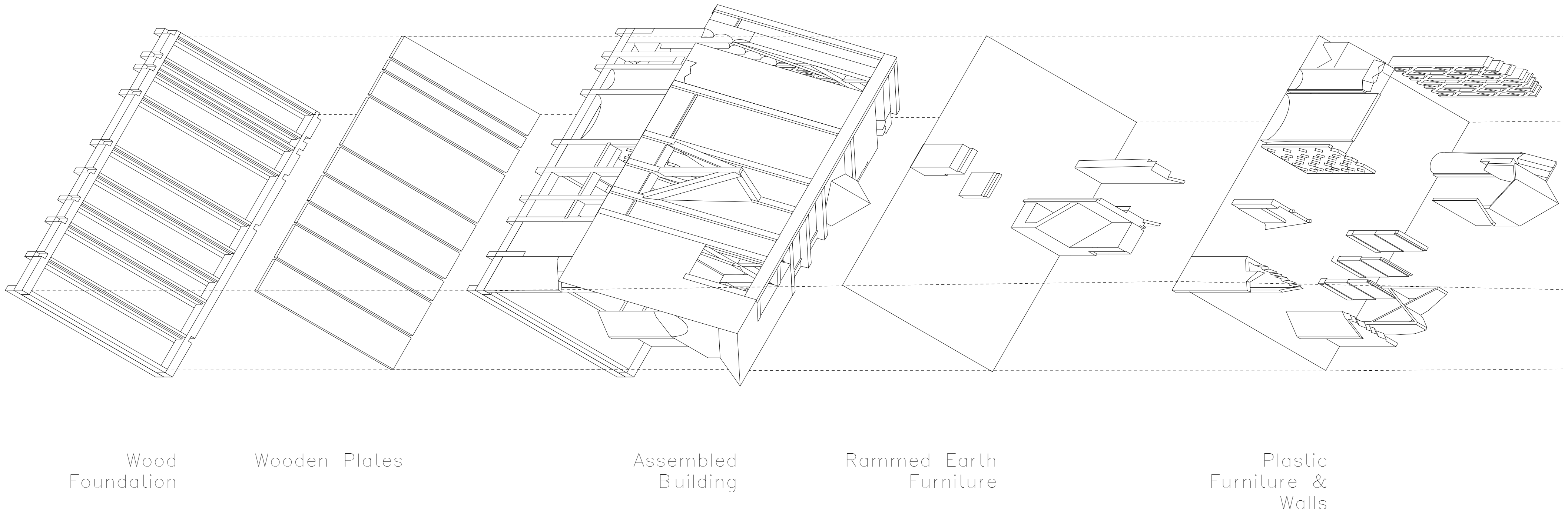
Generation 8
Final Design Hybrid



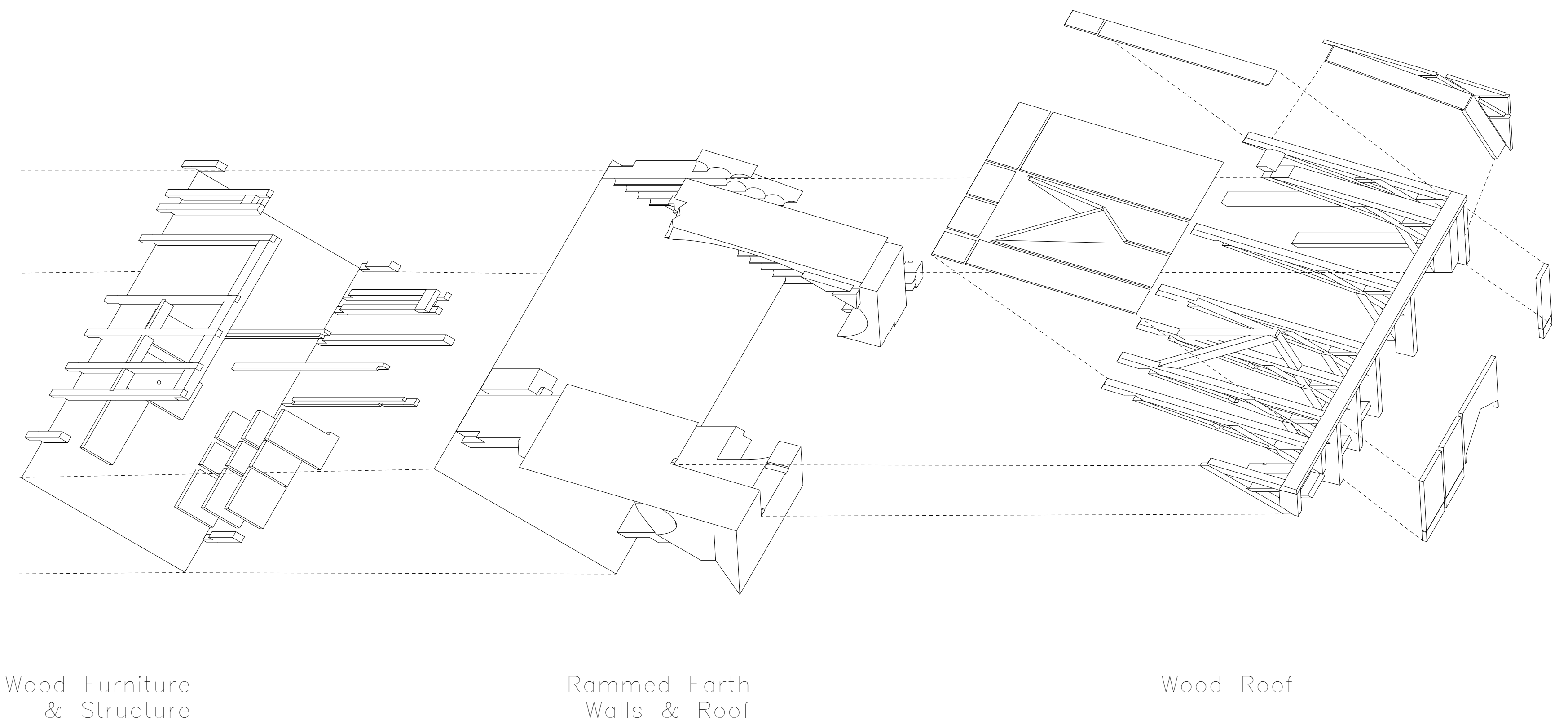
3d Section Hybrid
1:20

(A3)

Generation 8
Final Design Hybrid



Generation 8
Final Design Hybrid



Axonometry of Composite
1:100

(A3)

Conclusions

1. The Essential Aspects.
Materials do have an essence, or aptitude, as might be a better suiting word for what I have been investigating. The essence of a material is a mysterious thing which we look differently at in different times, but the aptitude is a more concrete description of the fact that different materials are good at different things. According to Ute Poerschke, the essence is when structure and surface are combined. It rarely is today, as materials like bricks are mostly used as wallpaper rather than structural pieces. As Stan Allen said, maybe looking at the material properties or aptitude is a better way to use the materials than to cover a concrete wall with bricks to get a brick wall.

2. The Material Indeterminacy.
The aptitude, or the catalogue of variations a material offers for a specific task, sets a determinacy for what the material can do. But even using the material in this "expected" way does not necessary lead to an expected result. Materials do set some limitations to an architecture but the architecture does not have to be limited due to the materials. My studies are not exactly traditional, even though they follow the materials' aptitude.

3. The Influential Processes.
There are more aspects than only the material which determines the essence. For rammed earth, the material and shape of the molds are as important as the material itself, the Neil Denari statement that concrete is all about what it flows into is true also for rammed earth. For plastic, the fabrication method determines the essence, as well as the manipulation of material properties. These aspects make the essence of a material wider and bigger, but still exist.

4. The Chimaera Effect.
The combination of materials can actually increase the visibility of difference and the feeling of essence of materials even further than when separated. The differences between thickness, texture, shapes and precision is made clearer and, here, stranger when put into one artefact than several. This project is not only about showing what the materials are good at, but their differences and peculiarities. Some weaknesses, as the inflexibility of plastic and the bad precision of rammed earth, can be seen in the final result as well.

5. The Unexpected Tweaks.
The models show some imperfections, and a part of the essence could maybe lie there. In plastic, we have the rounded corners, or the unsmoothness of the layers, in rammed earth the cracks and rounded corners and in the wood meetings and also cracks. These imperfections make the materials more difficult to combine, but also more interesting (in this student's opinion). When put into the real world, other aspects come in here as well, such as behaviour in rain, heat etc.

6. The Humorous Sense.
Today, following the essence of materials has been put into a serious and minimalistic context, of architects such as Louis Kahn and Peter Zumthor (Poershke, 2013). These studies show that there is more than that in the concept. The result of a project following materials' essence can be humorous and strange as well.

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Figure 26-29. Byggmax (2017) (Electronic picture) Peter-10 From Monteringsanvisning on https://www.byggmax.se/stugor-och-friggebodar/friggebodar/friggebod-peter-10-4-obehandlad-p7103166
Figure 30. JoshEwwAhh (2006) Portuguese Pavilion (Electronic picture) From: https://www.flickr.com/photos/joshewwahh/166318588/
Figure 31. Mudford, G. (1967) Fischer House (Electronic picture) From: http://www.design-is-fine.org/post/52549080762/louis-kahn-living-room-of-the-norman-doris-fisher
Figure 33. Weyer, J. (2011) Neues Museum (Electronic picture) From: https://www.flickr.com/photos/47333265@N00/7183263436/in/photostream/