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REMOTE
ARCHITECTURE

J.W. VAN WEGEN
BIG HOUSE GRADUATION STUDIO

Master Architecture, Building and Planning
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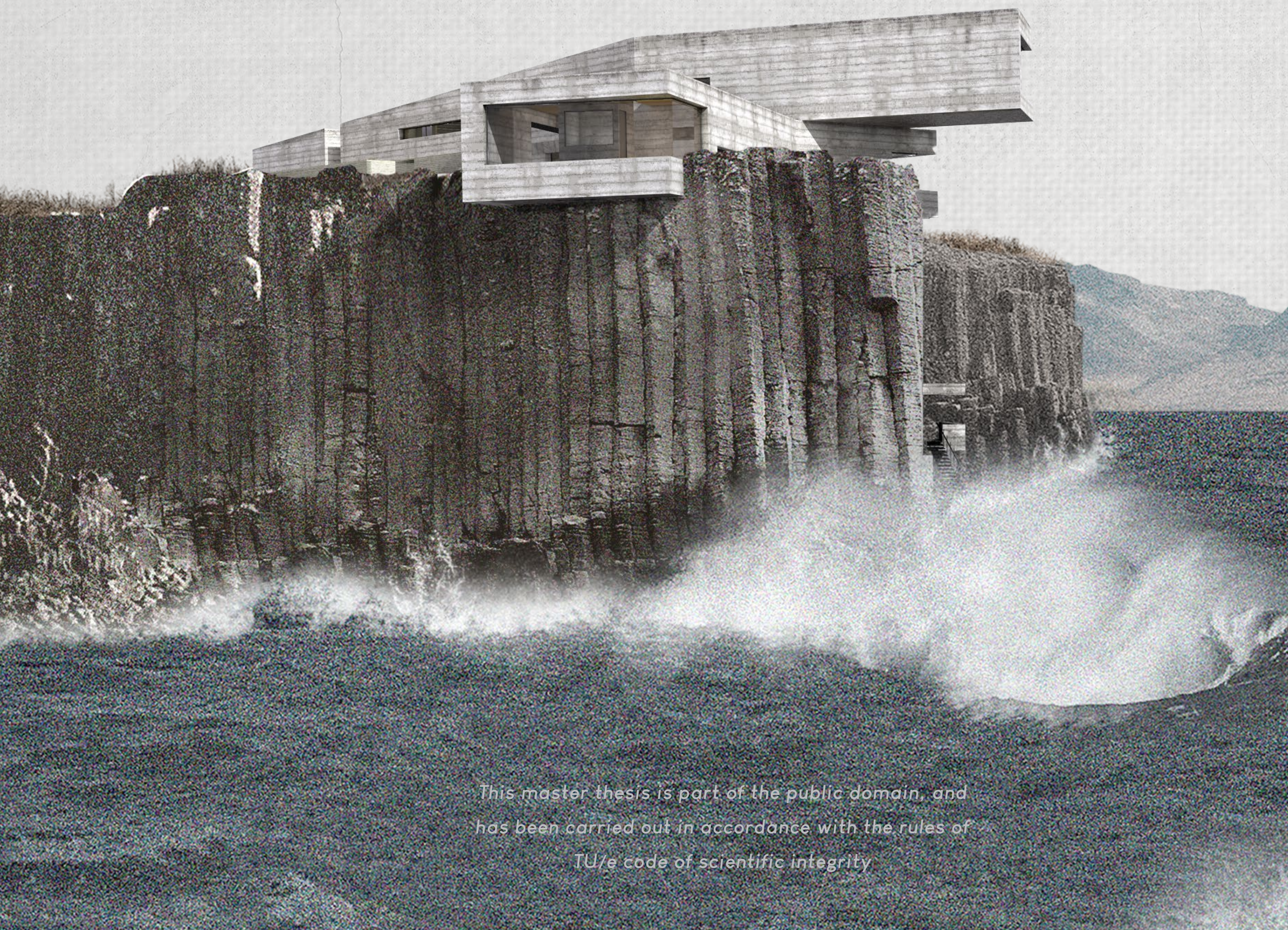

PREFACE

This research was conducted by the members of the Big House Graduation Studio of the first generation on behalf of the Architectural Design and Engineering (ADE) chair of Eindhoven University of Technology (TU/e).

The eventual aim of the studio is for each participant to individually design a Big House. In order to come to a justifiable design, the contemporary state and potential future of such Big Houses needs to be explored. This research is a first exploration into Big Houses. Will this type of house survive, and if so, what will the future hold?

Particular gratitude is expressed towards our tutors; Juliette Bekkering, Christina Nan, Jan Schevers and Zeeshan Ahmed.

PROJECT SUMMARY

When looking at migration patterns of individuals, it can be observed that cities, or at least urban environments, are by far the most prefered location to live in. This urbanisation trend is starting to affect more rural communities in most of Western Europe. Especially in rural Scotland, where the Clearances of the 18th and 19th century already depleted large parts of the more remote Highlands and Islands, the remote communities have been hit hard by this trend. Impacts include an ageing population that enjoys less local services and older generation that is left to reside in an increasingly emptied out rural environment, as the younger generations move on to better career prospects that the urban centres have to offer.

In Scotland, however, a small island named Ulva, which has been facing a decreasing population for centuries, has started fighting back. The island was recently bought by its inhabitants, and they are hoping to repopulate the island by launching various initiatives that they hope will attract new residents.

The question is what is needed in such a remote living community to help revitalise it and help its population sustain a self-sufficient existence that will attract new permanent residents? To this end, it is important to create tight-knit communities. But how does one achieve this? Various current trends might act as a catalyst to achieve more populated remote areas, such as the surge in people wanting to live a sustainable life, and the increasing possibility to work from home. But how can one apply these trends and use them to the benefit of repopulating remote communities?

To help provide an answer to these challenging questions, a design proposal is made for the Scottish island of Ulva to help repopulate and revitalise the island. What the people of Ulva are missing is a decent place to come together once the population starts growing. They will need communal facilities that will help with the establishing of a strong and tight-knit community that can continue to grow for decades to come. They will need a space to come together, work and socialise. A place that is accessible for all of the community.

Therefore, a new building will be introduced to the island. One where multiple small households will live together using a co-living concept. The concept of co-living will help establish a community feeling, which will in turn make the residents more invested in the rest of the island community. These residents will manage and maintain a small estate that is self-sufficient in its own right, while accommodating in space for the community of the island at large, for various functions.

In the end, a strong cohesive ensemble of buildings has been designed. The ensemble enables the residents to live in a remote location in a sustainable and self-sufficient manner. The ensemble offer the residents every possible way to make a living and provide for themselves in their everyday needs. Tourism and the production of food will be an important part of that. The buildings exert themselves in a manner that is in harmony with the location. It creates a safe haven for its users, both inside and outside, and it allows its users to optimally enjoy the location, as it embraces its remoteness in all respects.

At the same time, it will become a landmark to the community of Ulva. A place that can grow along with the population of Ulva, and one that helps them do just that. It is a place where the locals can come together, socialise, and plan the future of the island.

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INTRODUCTION

This booklet is divided into three segments. The first two segments are collaborative researches that were conducted as a part of the Big House Graduation Studio. These researches form the context for the third part of the booklet, which is the individual part of the project.

At the heart of this graduation studio is the concept of the Big House; an architect-designed private house. This concept will be further defined and more extensively explored in the first part of the research. We will look at trends within various themes, and ultimately we will see what position the Big House has in our current society, and we will speculate about the future of the Big House.

The second part of this booklet consists of an exploratory research into the field of digital fabrication within the construction industry. Within this research various trends that have the potential to change the industry will be identified. One of these promising new techniques will be further explored until the point of a working prototype.

The last part of this booklet will bring these two other segments together by diving into one of the challenges that was identified in the Big House research, which will then be tackled by means of a design, while keeping digital fabrication in mind as a helpful tool.

REMOTE
ARCHITECTURE

"No house should ever be on a hill or on any-thing. It should be of the hill. Belonging to it. Hill and house should live together each the happier for the other."

Frank Lloyd Wright

PART I

THE FUTURE OF THE BIG HOUSE

INTRODUCTION

This part of the research is a collaboration effort from Eva Boon, Lars Breukelaar, Roy van der Heijden, Michiel Peeters, Annine Rozema, Jorn van Wegen and Jorik van der Zeijl as an exploratory research into the context of the Big House as a part of the Big House Graduation Studio.

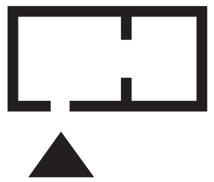
This research will explore the Big House as an architectural type, on how it is being used to reflect our needs and individualistic desires. The Big House is in essence a tailored suit to each individual client that showcases the top of the market resources. It is therefore that the Big House holds a unique position within the realm of architecture. Among the architecture community it is seen as a place where the most intrinsic architectural language of a designer is inevitably interwoven in its expression. Whereas outside the architecture community, a Big House is esteemed as the most tangible but also the most elusive concept within architecture, one that has been speaking to the imagination of all since its very conception.

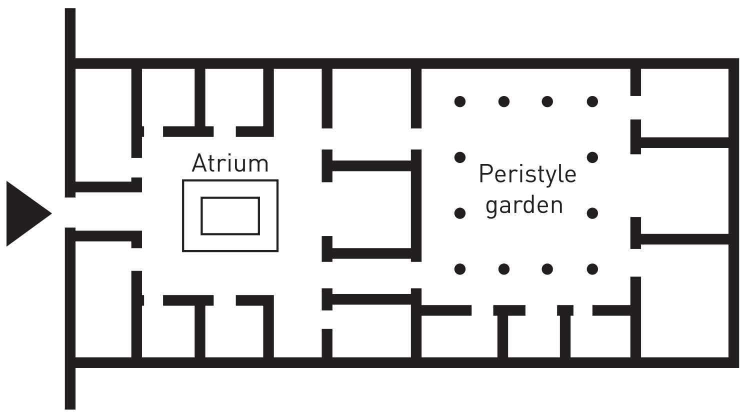
The Big House for the purpose of this research will be defined as an architect-designed private house, with various constraints that narrow down the scope of this research. Firstly, the Big House is obviously by definition designed by an architect. On top of that, it needs to possess some kind of grandeur, in terms of it being held in a higher regard within the architectural community. The 'big' in Big House does not necessarily refer to its size, but rather to the idea of living large in terms of for example exclusivity, location-wise. However, the concept of tiny living is excluded from this research, as the Big House will be defined as at least a medium sized private house. The clients for these Big Houses are mostly middle and upper class, although we will see that a Big House does not have to be expensive. The users that occupy and build these Big Houses are very diverse, as family compositions are changing and new ways of living are emerging.

We will see within this research that the Big House does not exclusively position itself within the category of the private house, since the concept of the private house is changing and losing its original meaning. Throughout this research, the concept of the private house or the architect-designed private house might be used to talk about trends that are being observed within those typologies, which thus also might influence Big House design.

The research is done by initially conducting a literary study on the topic of the private house. From this, a general history of the private houses of the upper classes is being explored as a first chapter. In the following chapters trends in private house design are being explored within the context of various architectural themes, after which analyses of various relevant case studies of Big Houses are being applied to these trends to draw some general conclusions regarding developments in Big House design within the context of these themes.

THE EVOLUTION OF THE PRIVATE HOUSE





The first image shows a stoneage house, which is basically a two room shed. The second image shows a traditional roman style villa.

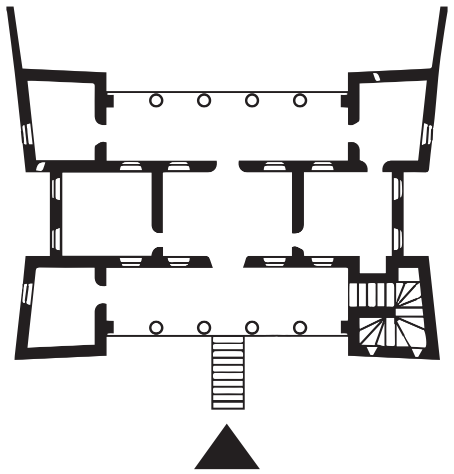
THE STONEAGE & ROMAN TIMES

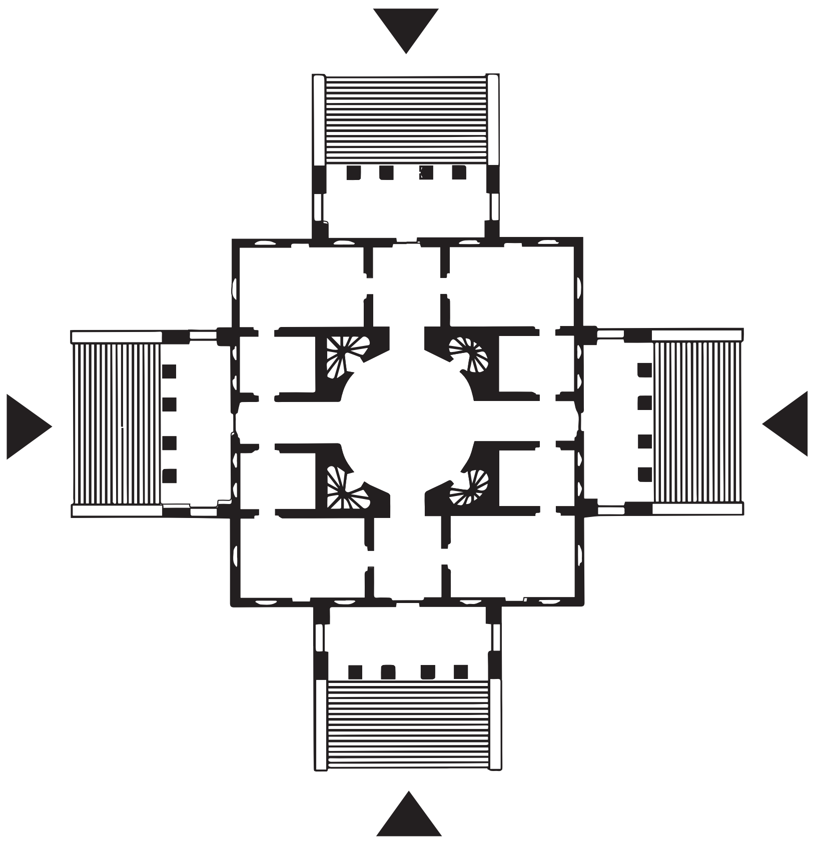
How has our notion of the Big House, as defined in the introduction, come to be and what forms did it take on through history? In order to fully understand the concept of the Big House, there has to be a basic under¬-standing of its history. Society has changed throughout time which has had a large influence on the big house through, among other things, its availability to differ¬ent classes of society. In tandem with this, the form of and reasons for the big houses have changed, often combining old and new believes. In this section the scope will be broadened, as we will be looking at the evolution of the private house, and within that framework we will identify various early notions and variants of the Big House.

THE FIRST BIG HOUSE

The very first built houses date back to around 10,000 years ago, when humans started moving out of their caves. They moved onto the land which they started to cultivate (Gardiner, 2002). The houses of the time remained little more than a shelter with a separation between a living and sleeping area, illustrated in the first image on the left. From then on, different layouts and dimensions started occurring. These forms of shelter were all very generic and came nowhere close to our current notion of the Big House.

The Romans introduced the villa urbana, which was the first housing typology that resembled our current notion of the Big House. Unlike the villa rustica, which was primarily used as a farmhouse with servants to generate wealth, the villa urbana was in effect a rural retreat (Rykwert & Schezen, 2000) (Ack¬erman, 1990). It was situated just outside the periphery of the city, and was not meant as a rejection of the city, rather as a complimentary lifestyle (Ree et al., 1992). Both inside and outside orientations occurred, the second image on the left illustrates an inside variant. Living quarters were turned towards the light, coming from the atrium and peristyle garden.





The first image shows a fortified villa from 1520 with the name Baldassari Peruzzi. The second image shows Villa Rotonda, designed by Andrea Palladio.

THE RENAISSANCE

DOWNFALL AND REAPPEARANCE OF THE BIG HOUSE

With the fall of the Roman Empire, villas were increasingly fortified to keep invaders and looters at a distance. Eventually the type villa disappeared from the architectural vocabulary. Private houses stopped existing in the form of country houses since they were, at the time, rarely more than occasionally occupied hunting lodges (Rykwert & Schezen, 2000). The upper-class began to live in fortified rural estates or castles instead.

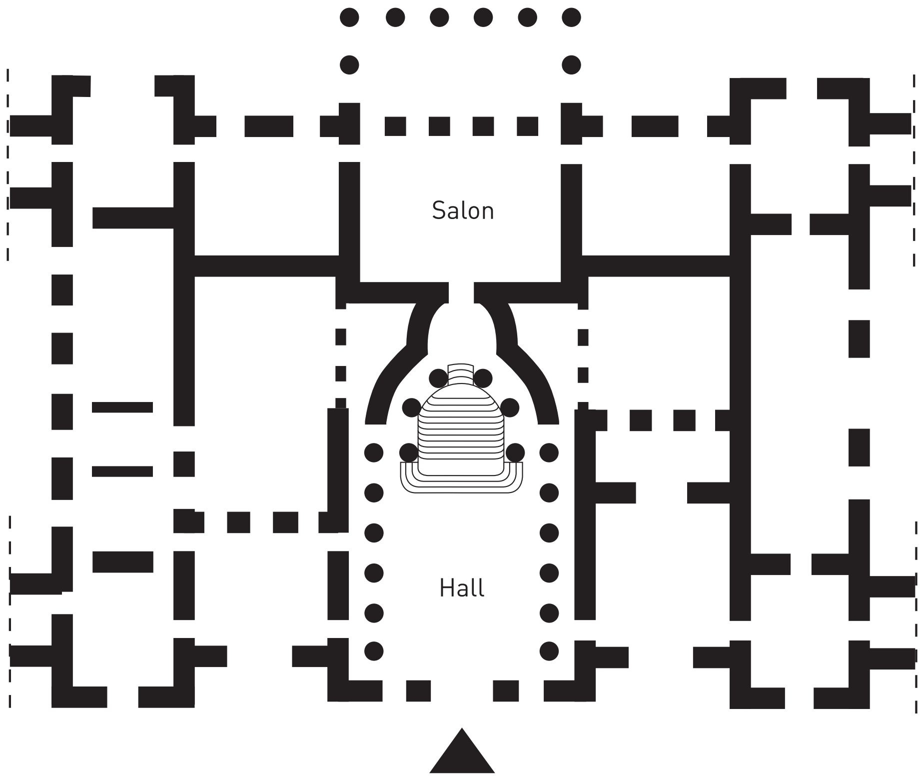
The Big House made its reappearance in the shape of the villa in fifteenth century Italy. This reappearance was the result of the decreasing need for houses to be defensible. The re-conception of the villa originated from merging the castello (fortified house) and the podere (farmhouse) (Ree et al., 1992). An important aspect of these villas was the relationship between the house, the garden and the landscape (Ree et al., 1992). The image on the left shows an example of this type with four defensible towers in each corner and a more open front and back side with columns.

THE BIG HOUSE THROUGH EUROPE

After its emergence in Italy, these types of private houses quickly spread throughout Europe. Especially in France, these ideas were successfully copied and transformed into their own versions; the hôtel and the chateaux (Thomson, 1984). The peak of private house design in the Renaissance Era took place in the sixteenth century, when Andrea Palladio designed a series of villas and farmhouses near Vicenza, Italy.

The most famous example of this is Villa "Rotonda", shown on the left, which is open to all sides so the different views could be enjoyed and the most important room in the centre of the building. It was lifted of the ground one floor and could only be accessed using one of the four main staircases on the outside.

When the renaissance in Italy reached its peak, it was only just starting in England (Gardiner, 2002). The working middle class was getting richer, and London was growing at an unprecedented rate (Cooper, 1999). The Gentry, the upper-middle class, was trying to escape the polluted city, while remaining able to enjoy the urban pleasures. These Gentry houses did not serve the traditional role of the country house, as they were in fact urban villas, erected in the suburbs of the city of London. They could be distinguished from other large houses because of their more recreational and laid back character, with gardens forming an intricate part of the villa. In this, they strongly refer back to the Roman villa urbana. Furthermore they did not adhere to hierarchical forms of the upper-class houses in the city (Cooper, 1999).



Holkham Hall, designed by William Kent in 1609.

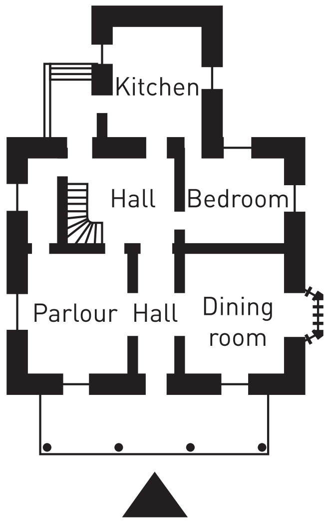
THE BAROQUE

In Italy and France, the Baroque followed up the Renaissance Era, and resulted in more dynamic and more ornamented houses, such as Villa Giulia in Rome, Italy (Norberg-Schulz, 1971). Already in the Renaissance Era, the distinction between the town house and the country villa made its reappearance, but in the Baroque Era, this distinction was defined even stronger. These types how¬ever did not serve two different types of society, but rather two sides of the same class of people (Norberg-Schulz, 1971). Leon Battista Alberti defined the distinction between the two as follows:

"The country House and Town House for the Rich differ in this Circumstance; that they use their Country House chiefly for a Habitation in Summer, and their Town House as a convenient place of shelter in the Winter. In their Country House therefore, they enjoy the Pleasures of Light, Air, spacious Walks and fine Prospects; in Town, there are but few Pleasures, but those of Luxury and Night."

Alberti, op. cit., V, xviii

An important development in the Baroque Era is the more inwards turned character of the houses, contrary to the houses of the Renaissance Era which were defined by their relation with nature (Norberg-Schulz, 1974; Ree et al., 1992). In the Baroque Era, the salon became the most important room in a house and was usually centrally located in the floor plan. The prominence of the staircase grew as well, since it was no longer hidden away as was common in Renaissance houses (Norberg-Schulz, 1974). Built in the late Baroque Era, Holkham Hall, shown on the left, clearly shows the importance of the salon as well as the growing prominence of the staircase. Rather than being raised a floor like Villa Rotonda, Holkham Hall has its main entrances on ground level. Instead the stairs are located inside in a grand entrance hall, with the most important room, the salon, still located on the first floor after the stairs. Both the main stairs and the salon are located in the absolute centre of the building with more private functions of to the sides.



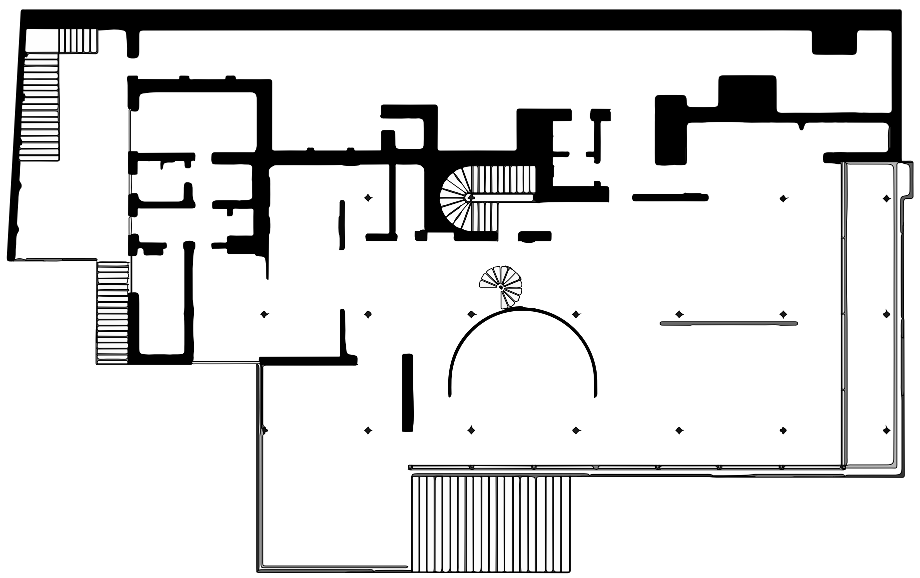
17th century English cottage.

17TH CENTURY ENGLAND

APPEARANCE OF THE CURRENT NOTION OF THE BIG HOUSE

In seventeenth century England, the big house as we know it today emerged. The upper class was getting wealthier, which allowed them to physically separate their house from their wealth generating source. Their workplace and living place were separated by relative large distances which were travelled by coach ever day (Girouard, 1985). This meant that the houses became pri¬vate spaces for the owners (Melhuish, 2000). With the industrial revolution of the eighteenth century, improved transport further stimulated this commuting lifestyle (Girouard, 1985). This lifestyle became especially prevalent in the United States where, for example, factory directors would move daily between their home and their work, using steam powered vehicles.

The industrial revolution often generated wealth in cities, not only for merchants and factory directors, but also for the working middle classes. They tried to physically separate themselves from the city, which, because of the industrial revolution, had severe climatological, sanitary and aesthetical disadvantages (Dauber, 1985). This led to a blend of suburban houses, with differences based on the esteem of its owners. In England, the most prosper¬ous industrial country of the time, the terms for detached private houses started to blur (Girouard, 1985). The mix of villas, gentlemen's houses, gentry houses, cottages and the like, made the term 'villa' lose some of its prestigious sentiment. An example of this is the cottage shown on the left. Public functions such as the parlour and dining room are located in the front with more private and work related rooms like the kitchen in the back.



Villa Tugendhat, designed by Ludwig Mies van der Rohe in 1929.

MODERNISM

The nineteenth century saw some of the first planned subur¬ban areas, which demoted the prestigious villa to an even broader audience. The middle classes began to pursue high-end ideological and cultural matters (Dauber, 1985). But there was still one main difference between upper class houses and middle class houses; the middle class was concerned with quantity whereas the upper class was concerned with quality. The middle class imitations had rich external features, but lack internal serenity (Dauber, 1985).
During the interwar period, modernist ideas first came into contact with house design, becoming the dominant form after the Second World War.

With it came the ideas of Raumplan and Plan Libre, both with their respective architectural ideals. In turn, many villas were based on the Plan Libre with glass walls and picture windows, carried by slender columns. This all to convey lightness and transparency of the building (Heathcote, 2000). An example of such a building is Villa Tugendhat, deigned by Mies van der Rohe, which can be seen on the left.

The late 20th century saw the rise of the post-modern move¬ment in architecture. Paradoxically this is not a style as such, instead being led by pluralism (Jencks, 1991). For traditional postmodernism the meaning of history has an important influence and following from this the same goes for ornament, context and historical allusion (Ghirardo, 1996; Jencks, 1991). Architects struggled to combine contemporary architecture with traditional styles and forms throughout the world (Ghirardo, 1996). For the design of houses this mend a stronger focus on historical allusion of the notion of the house in different cultures, as well as orna¬mentation.

THE FUTURE OF THE BIG HOUSE
USER & CLIENT

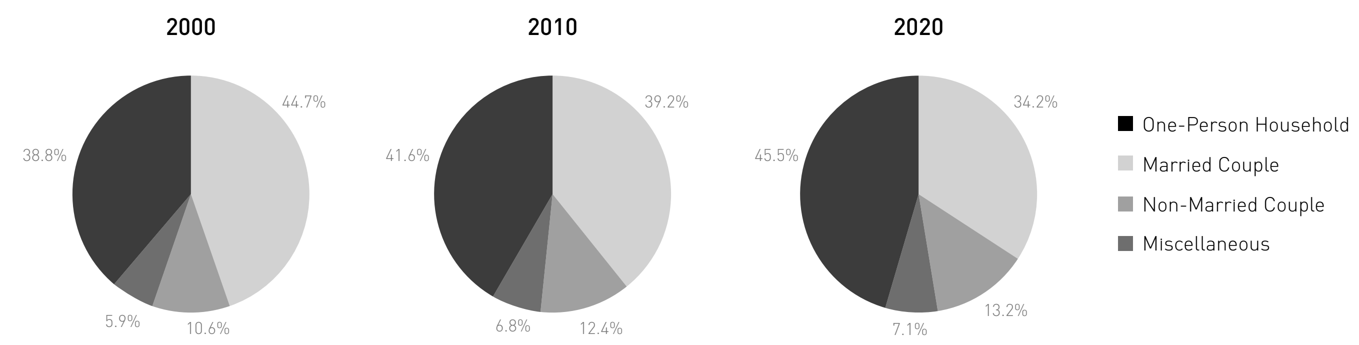
Photo © Hans Werlemann, courtesy OMA
Maison a Bordeaux, OMA. Built in 1998. The house is a supreme example of a building that is tailored to its user. The client was a wheelchair user who wanted this house to be complex and ineresting, due to it deflning most of his world.

INTRODUCTION

Now that a brief summary of the highlights of Big House design throughout history has been established, the focus will be shifted towards contemporary architecture, and the Big Houses that it has produced.

One of the key aspects defining a house are its users. A house is a place where someone lives and spends most of his or her time. Each client has its own demands when it comes to lifestyle and living. Often, the architecture of the house is the literal translation of these demands into physical form. When discussing the future of big houses, it is therefore useful to look at trends regarding the clients. The architecturally designed private house used to be solely reserved for the wealthy, but is this still the case? What are modern client's demands and how can we see that back in the design of the house?

To formulate a justifiable conclusion, household demographics, current and potential clients of the big house will be investigated. This will be supported by case studies which will demonstrate how clients can, or cannot, have influence on the design of their big house.



Household compositions over the last 20 years. Source: CBS

HOUSEHOLD DEMOGRAPHICS

Before anything is claimed about household compositions and their future, it is important to note that trends seldom continue indefinitely. Demographic trends are embedded in a political and social context (Poleg, 2020) and therefore vary widely in different place and time.

TRADITIONAL NUCLEAR FAMILY

However, one trend that has stood upright for many decades is the single family in a private house. The traditional nuclear family consists out of a couple who got married as soon as they could, got kids, bought a house, and worked a job that was aligned with their mortgage (Poleg, 2020). This ideal picture has long been sustained in the Western world.

DEMOGRAPHIC SHIFTS

As stated previously, this ideal was embedded in a contemporary context. When this context shifts, the ideal itself shifts with it. The greatest driver of such a shift is a decline in amount of traditional nuclear families. In the nineteenth century, three-generation families were long common (Hildner, 2013; Melhuish, 2000) and until a few years ago, the word household was synonymous with family (Krisch, 2013). The nuclear family currently is no longer the most dom¬inant from of living, as can be seen in the figure on the left. The amount of marriages has also rapidly declined in the past 50 years, which leads to more single persons who have a harder time buying their own property (Jonuschat, 2012). However, the number of single-person households has seen a steady increase. Another demographic shift is the 'ageing' of the population. Where previously multiple children per family was normal, currently only 1.7 child per family is average (CBS, 2020). This means that the group of elderly is getting larger, while the addition of youth is lacking. All these demographic shifts have led to a multitude of living arrangements, rising cohabitation, declining household sizes and a rise in individual autonomy alongside of weakening social cohesion (Rowe & Kan, 2014).

In general, smaller forms of cohabitation have emerged in today's housing market. The traditional nuclear family has eroded into a number of smaller units, from childless couples in shared or individual homes to single-parent families or singles. Most of these forms of living have always existed, in the past they were simply statistically less relevant (Krisch, 2013). Amid all these changes, the relationship between the individual and society is shifting towards the individual (Hildner, 2013) which means that the current private housing stock no longer reflects the different needs of modern lifestyle (Kuhn & Harlander, 2012). The individual contemporary dweller needs to find their own identity in a uniform housing industry.

THE FUTURE OF THE BIG HOUSE
USER & CLIENT

Jystrup project, designed by Vandkunsten Architects in 1982.
(Vandkunsten Architects, n.d.)

CO-HOUSING

CLIENT OF THE BIG HOUSE

The single-family private house is considered the most dominant form of housing in Western Society. The dream of a private house has been lodged deep in our subconsciousness (Krisch, 2013). According to Schittich, apart from a roof over the head, the private house symbolises something personal and individual. Schittich describes the ideal of the private house as follows:

"... the private house has symbolized a roof over the head, the desire for privacy, for a piece of land we can call our own. At the same time, it is a status symbol, an expression of personal freedom and individuality. For within our own four walls we can do as we please, with no interference."

(Schittich, 2013, p. 9)

ALTERNATIVE CLIENTS FOR BIG HOUSES

However, from the seventies onwards, we see a new type of client emerging. Under the term co-housing, multiple clients collectively create new forms of community housing (Kuhn & Harlander, 2012). Cohousing usually consists of multiple individuals or families, with different backgrounds and classes. By joining forces, several families combined can produce the leverage to build an architecturally designed house which they alone could not have built. They essentially give up some of their individuality to be able live larger. The condition for living in a big house is sharing the facility with others. In this way, cohousing can create new clients for big houses.

Pioneers in this field were Denmark and Germany, but other European countries were quick to follow (Wolpensinger & Rid, 2012). An excellent example of this is the Jystrup project in Denmark by Tegnestuen Vandkunsten which can be seen on the left. It consists of a single organism with 21 private residential units. Almost half of the facility is communal space (Vandkunsten Architects, n.d.). Despite not being the most recent example, it is part of Denmark's long history in cohousing projects ("bofællesskaber") and it may be regarded as a classic of this type (Wolpensinger & Rid, 2012).

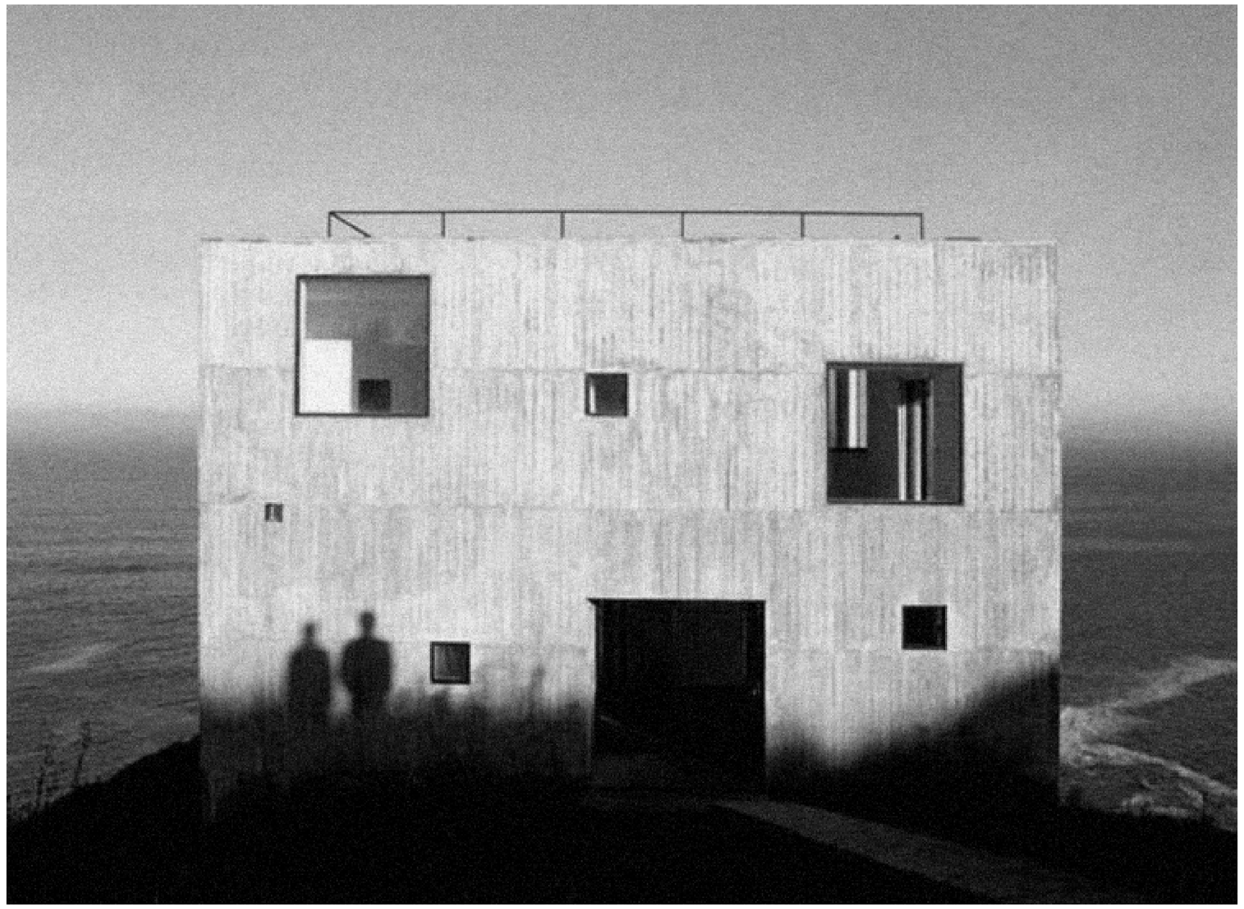


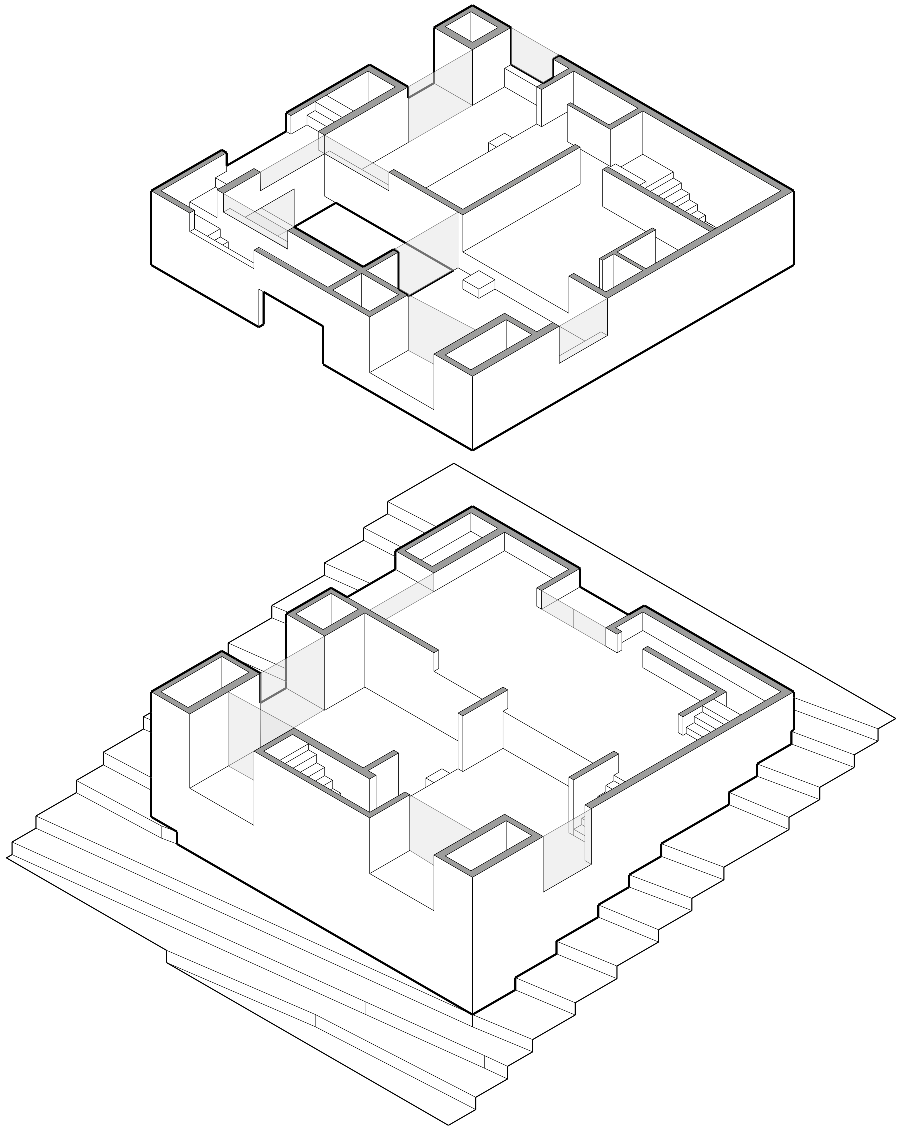
Photo © Cristóbal Palma
Pezo von Ellrichshausen, Poli house, Coliumo, Chile, 2005. Exterior view from the East.

CASE STUDY
CASA POLI

The architects of Casa Poli are Mauricio Pezo and Sofia von Ellrichshausen, a married couple who share an architectural practice. Together with another couple, they bought a plot of land in 2003 to build their own rural retreat, away from the busy city of Concepción, Chile.

Casa poli makes a great case study for the chapter User & Client, as the designers envisioned an extraordinary program that would not just fit the owners, but a community around it as well. The reason being that Casa poli was meant as a rural retreat for the owners, but it would be a waste to have it be empty for all year except a couple of weeks in summer.

This sort of thinking is challenging the traditional notion of the architect-designed private house. No longer is this house truly private, but instead, offers back to the neighbouring community.

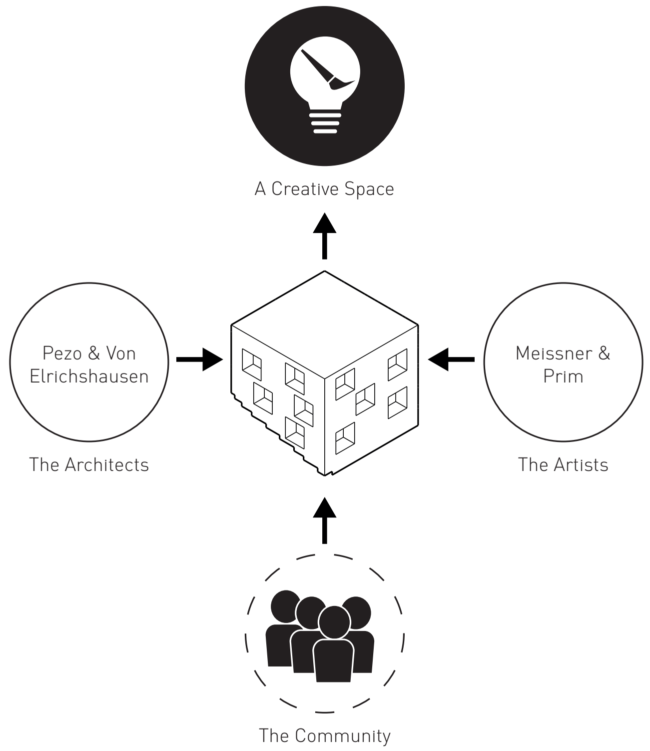


Casa poli, designed by Pezo van Ellrichshausen Architects in 2003. The special program of this houses makes this a great case study when discussing User & Client.

CASE STUDY
CASA POLI

CASA POLI

Initially, the plan was to build two separate houses to accommodate both their families. Soon they realised that that would not be possible for various practical reasons (Lind, 2008). When the architects started envisioning the program that would serve both families, they figured that it should be possible for the home to serve the community as well (UK Essays, 2018). The resulting double program entailed on the one hand an artists' retreat (the one family consisting of architects, and the other consisting of a writer and a sculptor (Lind, 2008)) while on the other hand it would function as a cultural institution that could be used flexibly as for example an exhibition space. The challenge for the architects was thus to create a house that felt domestic and comfortable, while on the same time providing a creative stimulus to the artist side of both families, while also providing the flexibility needed to serve the community.



The fact that the architects were their own clients, creates a unique situation for a rural retreat. Their creative freedom was however toned down by them not being the only clients, as the befriended couple would be sharing the resulting private house with them. On top of that, the agreement they made amongst themselves meant that the community became a silent client as well. What made the resulting project work so well, might be their common interest; creativity. The house, which is in effect an artist's retreat, is built for the two families, who all have creative professions. That side of them, that binds them together is also what was used to make it available to the community, in the form of a cultural institution.

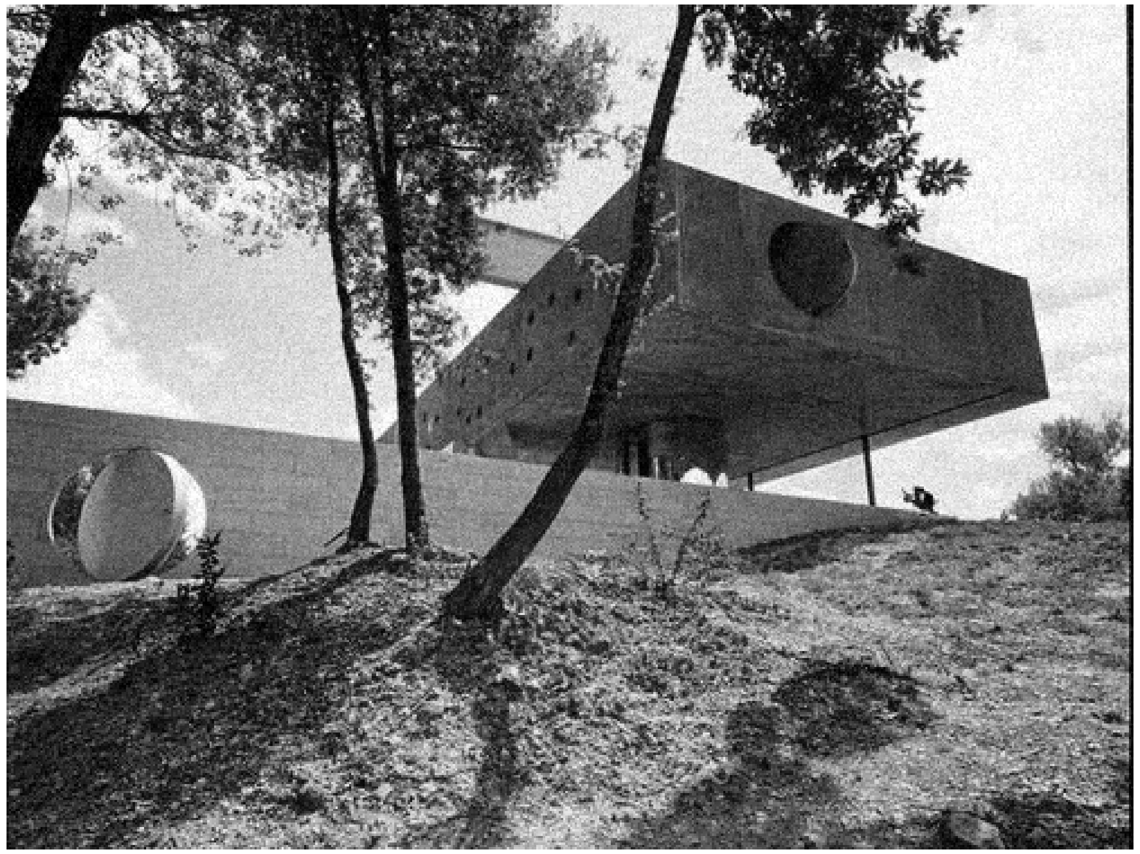
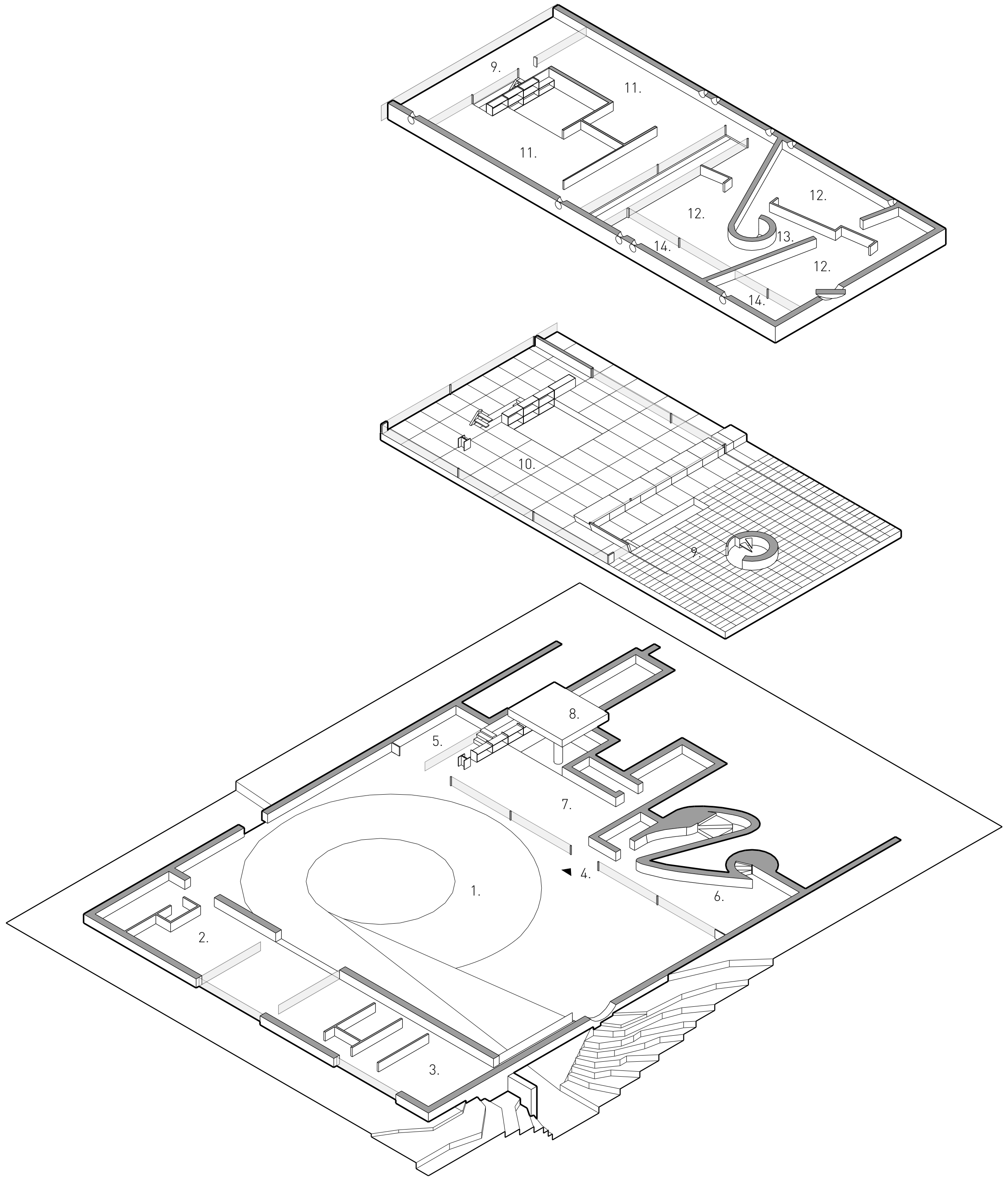


Photo © Hans Werlemann, courtesy OMA
Maison a Bordeaux, OMA. Built in 1998. The house is a supreme example of a building that is tailored to its user. The client was a wheelchair user who wanted this house to be complex and inneresting, due to it deflning most of his world.

CASE STUDY
MAISON A BORDEAUX

Maison à Bordeaux may be considered as an excellent example of architectural exercise where there has been a firm relationship between the client and the architect. The client for the house in Bordeaux is a French married couple with three children. They used to live in an ancient house in Bordeaux. For several years they were thinking about building a new house (Riley, 1999). The life of the wealthy couple, comprising Jean-Francois Lemoine and his wife Hélène, faced a crisis when Jean-Francois was involved in a car accident. This led to him being dependent to a wheelchair.

Obviously, this changed all content of previous considerations about realizing a new home. Their current residence did not properly meet the requirements of the husband's new life conditions anymore. Rem Koolhaas was asked to design a new home that would liberate Jean-Francois from the limitations their current house was stuck to (WikiArquitectura, 2014). What makes this project particularly renowned, is the way the architect dealt with the very specific demands of the client due to the wheelchair complications. Rather contrary to what one would expect, the client desired a complex house instead.



Maison a Bordeaux, designed by Rem Koolhaas in 1998. The house is a supreme example of a building that is tailored to its user.

CASE STUDY MAISON A BORDEAUX

"Contrary to what you would expect, I do not want a simple house. I want a complex house, because the house will define my world."

(J.F. Lemoine, as cited in Melhuish, 2000)

Where one possibly might expect a one-level residence, Maison à Bordeaux comprises three simple volumes with all their own spatially complex architectural value. Making all floors interconnected and therefore reachable for the husband, is ensured by an elevator platform functioning as the heart of the house. Both in architectural and user-friendly terms, the platform is responsible for the continuously changing spaces of the house. All facilities one needs to live a comfortable life are arranged around the elevator platform to alle¬viate the daily routine of the husband. Therewith, the 3 x 3,5 meters platform autonomously figures as an office space for the man.

The architect tried to closely respond to the restricted movement possibilities of Jean-Francois. The design embraces a definite amount of complexity by the elevator platform and the distinctive stacked floors, considering the wheelchair situation. Both the masterful innovation and the given that all family members can live a comfortable life, make the house show that architecture as a language can establish a firm relationship between the architect and client.

Photo © Cristóbal Palma
Pezo von Ellrichshausen, Poli house, Coliumo, Chile, 2005. Interior view.

CONCLUSION

INDIVIDUALISM
The place of the architectural designed private house within society is changing and will continue to change in the future. The main trend that has initiated this shift is the decreasing amount of traditional families and the increasing amount of alternative house¬hold compositions. It is also apparent that the household size is decreasing and social cohesion in society is decomposing. A general trend towards individual autonomy is in process.

EXPRESSING STATUS
The architect designed private house has always been a manifestation of the lifestyle and individual personality of the client. Villa architecture has long been linked with personal prestige or esteem. Letting a famous architect build your residence is one way of expressing this prestige. For the Tugendhat house, the family particularly commissioned Mies van der Rohe as their architect. Similarly, the Ennis house and Maison à Bordeaux were designed by world-re¬nowned architects Frank Lloyd Wright and Rem Kool¬haas respectively. With the inequality of wealth being ever more visible in our current society, the trend of expressing one's status will by no means decline in the foreseeable future.

ALTERNATIVE CLIENTS
Another current trend is the rise of alternative forms of living together. With an individualising soci¬ety, the housing market no longer reflects the contem¬porary demands for users. This asks for alternative types of habitation. Cohousing initiatives are bringing together forces who are collectively eligible for a new type of big house. Multiple individuals or families become one organism for which to design both individ¬ual dwellings, as well as communal space. An example of this is Casa Poli, where there two sets of clients, alongside the community all use the house. The overarching concept of a cultural institution is what ties the house and its users together.

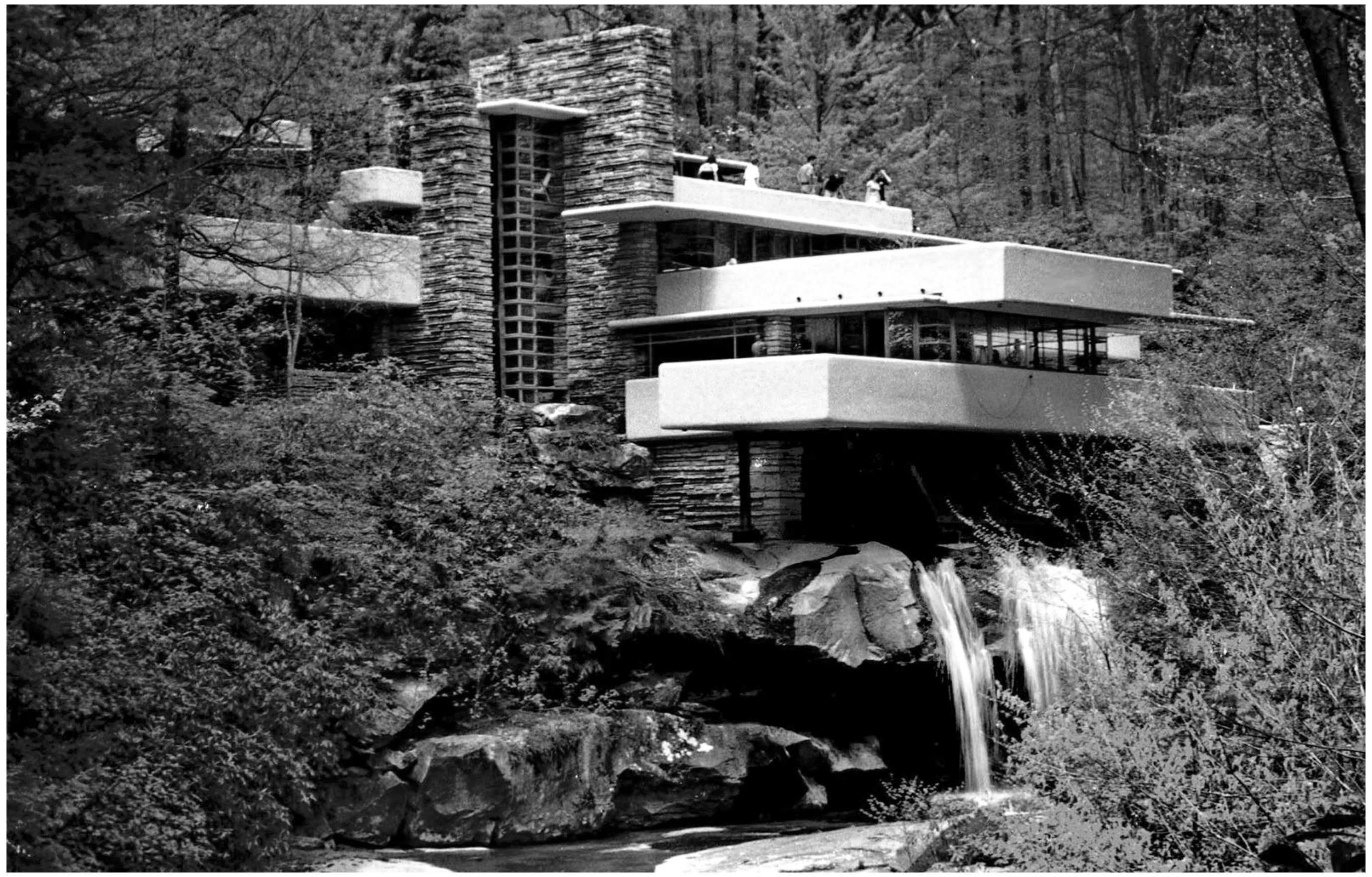
RELATION CLIENT & ARCHITECT
In general, the client and the architect work closely together in a private house project. This relation is expressed in the design of the house, which often leads to tailored, unique designs. Clients can have great influence on the design, such as Maison à Bordeaux, or the Möbius house. In other cases, the architect is voluntarily left free to design as he or she pleases, such as Villa Tugendhat. Where the views of the client and architect diverge, conflicts can occur, and the house can suffer. This was the case with the Ennis house, where the building was not finished according to the design of Wright due to conflict between him and the client. The relation between the client and the archi¬tect can take many forms, and it can have great impact on the design of the house.

LOCATION & CONTEXT

Photo © Cristóbal Palma
Pezo von Ellrichshausen, Poli house, Coliumo, Chile, 2005. Exterior view from the north.

INTRODUCTION

Since Roman times the wealthy have opted to live outside the city (Ackerman, 1990; Woods, 2013), while in modern society, the location of one's residence seems to be a free choice. Whatever the location, every house has a relation with its surroundings and it would not be very useful to discuss housing in isolation; without looking at its connection to context or the lack thereof (Rowe & Kan, 2014). In order to discuss the topic of the future of the Big House, it is important to understand the incentives behind their location. What trends can be observed in terms of location and why do these people choose to live there?



EXCLUSIVITY

In cities, residential space is limited due to dense population. This gives the challenge of alternative forms of living, such as shared facilities and cohous¬ing. Multi-functional use and new housing typologies are therefore being sought and explored since about 1990, particularly by middle and lower classes (Rowe & Kan, 2014). These alternative forms of living densify habitation even more and they blur the boundary of privacy within residences.

The upper-class is hardly affected by these trends because they can, and always have, bought their exclusivity. From Roman villas, Medieval castles, English land house, the suburbs and more recently, gated communities; acquisition of private land is, and has always been, dependent on wealth (Woods, 2016). These acquisitions were mainly outside or on the edges of the city or even beyond that, as to socially and spatially differentiate oneself from lower classes. An example can be found on the left. Falling Water, designed by Frank Lloyd Wright, provides a luxurious residence away from the city. These kinds of specific locations can vary depending on the client, but usually involve certain sought-after assets (e.g. a particular view, a desired landscape, a specific relation to nature, etc.). These assets are what distinguishes their plot from the repetitive suburban plots, which excludes their house from suburban houses. These locations therefore do not only show off their wealth, but also reflect their exclusive position in society. In this case the waterfall and nature are specific assets that were used by the architect to design a weekend retreat for the family (Falling water Org, n.d.). The upper-class lived and still lives in a private bubble, disconnected from the life of the vast majority of the world's population (Beaverstock et al., 2004).

Political power that is associated with wealth often also provided the required leverage over the popula-tion. Even in today's society, political influence can be a powerful tool, particularly to limit the supply of prop¬erty in sought-after areas by resisting new develop¬ments. Exclusivity of a certain areas is ensured by this due to inflating land and house prices (Woods, 2016).

Photo © Gene J. Puskar/AP Images
Fallingwater, designed by Frank Lloyd Wright in 1935 and completed in 1937; near Mill Run, southwestern Pennsylvania. The picture shows a location with very specific assets, far beyond the city and serves as an example of what extreme wealth can result in.

Photo © Christian Richters.
On the picture, Möbius House by UN Studio is depicted. The house is located in the exclusive area 't Gooi in the Netherlands, where many large private houses are located. The attraction to this area is most likely the rural character and the space, while the area itself is close to most major cities.

DWELLING IN RURAL AREAS

MOVING OUT OF THE CITY

Today, wealthy elite continues to manifest themselves away from the city (Woods, 2013). The city has a history of being insanitary. From Roman times, those who could afford it spend their weekends and summers outside the urban setting or moved permanently to rural areas (Melhuish, 2000). This rural retreat became especially popular for the middle classes during the industrial revolution where the cities were booming, and health and safety were poor. With the introduction of new technology, such as the car, trams and advanced roadway networks, it became possible to permanently live further away from the city while keeping a job in the city. Middle class families left, leaving the working class to fester in their primitive, insanitary dwellings in the inner city (Barras, 2016).

Apart from health conditions, space also was a major consideration for the upper classes to move out of the city (Dauber, 1985). The availability of space in rural areas compared to the availability of space in cities is still considered a decisive factor. Woods describes three reasons how this space can nowadays be used to display wealth (Woods, 2016). First, the sole ability to buy private land is an expression of relative wealth; "the larger and more prestigious the property the greater the implication of wealth". Second, the land can be used to exhibit exclusive possessions such as buildings, landscapes, cars and the like. It also lends itself to exclusive hobbies or lifestyles (e.g., hunting, shooting, skiing, sailing, horse-riding, aviation, vineyards, etc). Finally, in many countries still, the status associated with rural land ownership in reinforced by culture; "romanticising the landed gentry as a pinnacle of exclusivity and privilege." (Woods 2016).

Moving out of the city, also called suburbanization, has evolved in various patterns in many cities, something which goes beyond the scope of this research. But a notion that can be observed is that middle classes have been taken over the suburb since the 1960's (Barras, 2016; Gillham, 2013; Poleg, 2020). The upper class residences have since the 1990's shifted to locations beyond the suburb. The main reason for this phenomenon what we call counter-urbanisation (Mitchell, 2004) is that the lifestyle of the suburb no longer reflects the demands for upper classes. Since the industrial revolution, suburbs have become more accessible for middle classes over time. This broad accessibility makes the suburb no longer exclusive, which in turn, makes it less attractive for the upper class who want to distinguish themselves.

This counter-urbanisation, however, seems to only take place among the upper class. For the middle and lower classes the city, or at least urban areas, seem to have the upper hand.

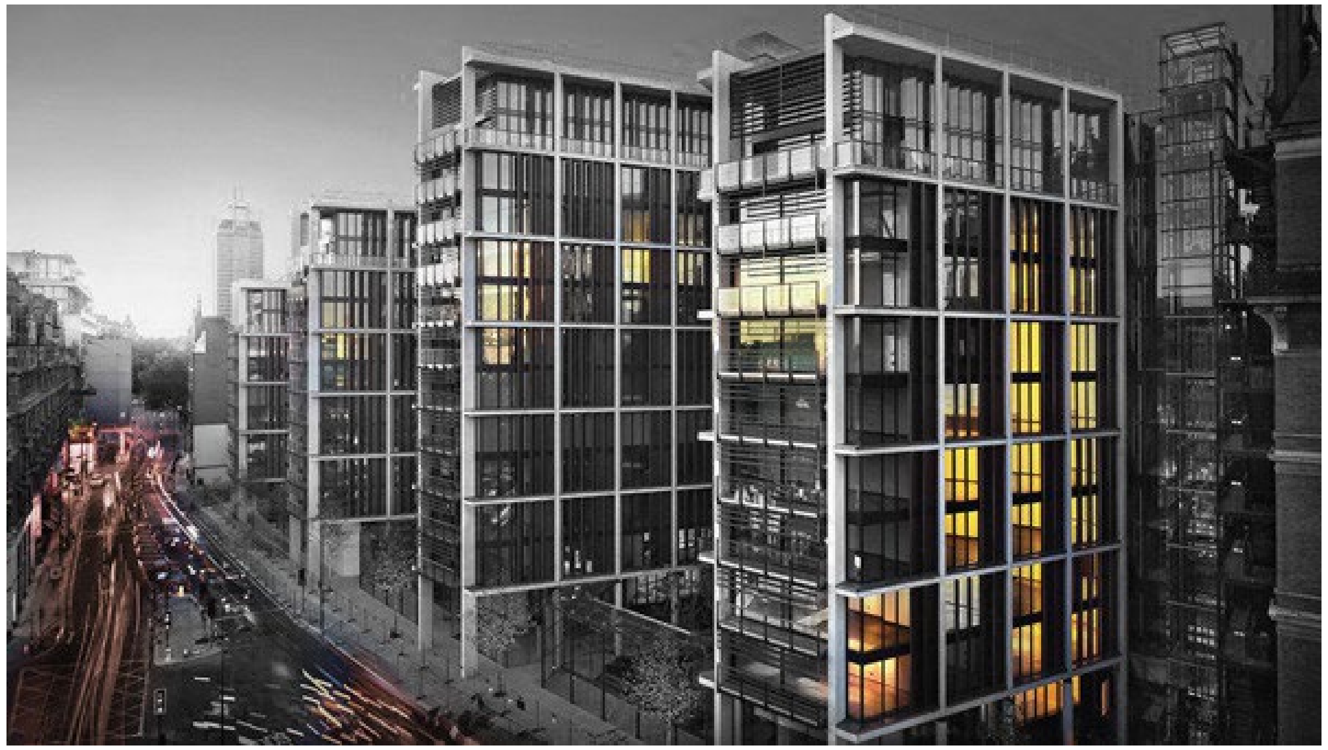


Photo © Laing O'Rourke.
One Hyde Park designed by Rogers Stirk Harbour and partners. Finished in 2011.

DWELLING IN THE CITY

The rural retreat is no longer alone in accommodating the contemporary upper class. Over the last 25 year there is been a growing reappreciation for the city as a residential area(Haas & Locke, 2018). Coming back to the city has a complexity of causes, different for each city, but a few general principles apply to all.

LIVEABILITY

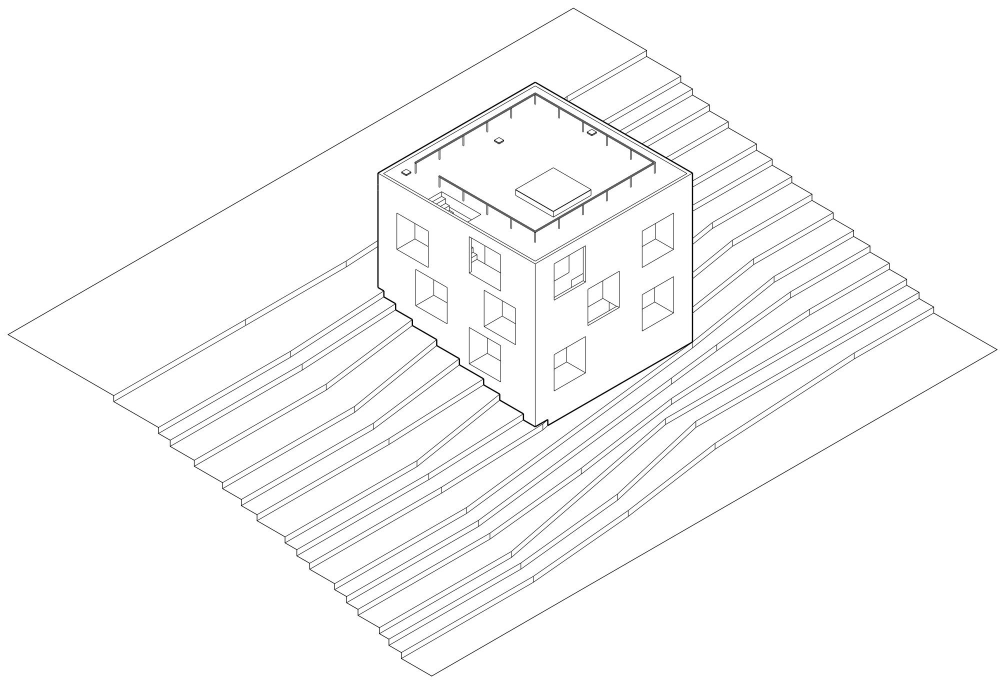
One of the causes is the improved liveability in cities, particularly city centres. The five leading trends that stand out are New Urbanism, Post Urbanism, Green Urbanism, Re-Urbanism, and Everyday Urban¬ism (Haas & Locke, 2018). None of them has taken the serious upper hand, but together they call for a more liveable city with greener public spaces and a densi¬fication of the city centre. Since the 1990's there is a wider acceptance of the more pluralistic range of city housing types (Rowe & Kan, 2014).

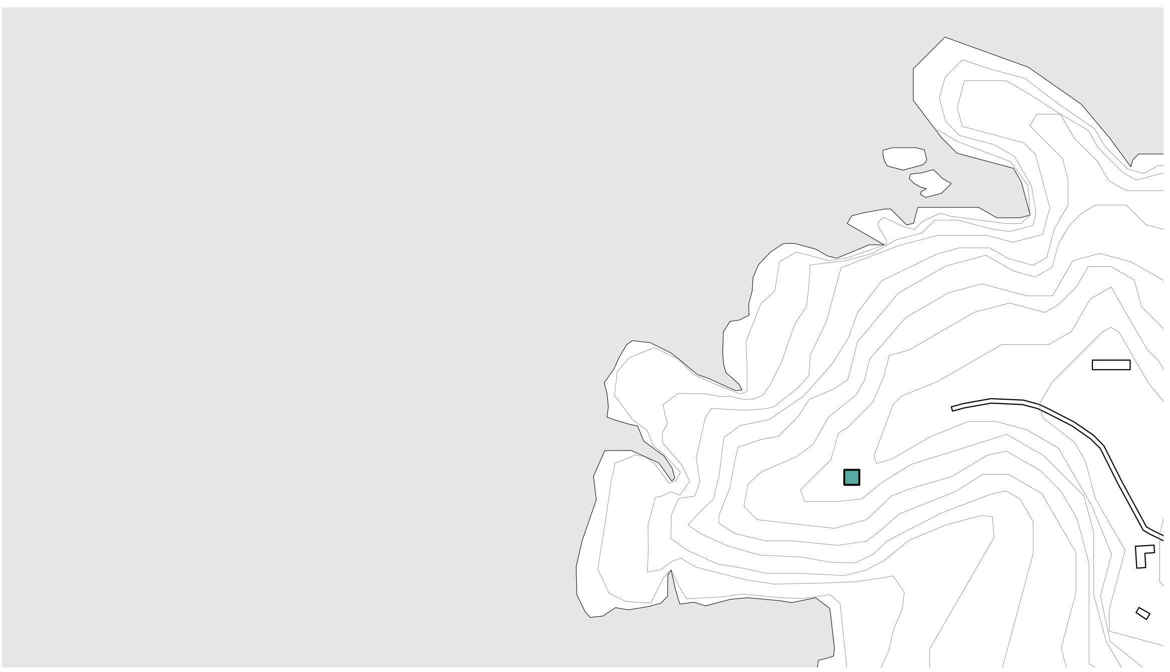
TROPHY HOME

Another cause is the metropolisation of major global cities. Where the country seat gave the expres¬sion of status and authority, the city house was the locus for political operations for ages (Barras, 2016). This trend is reoccurring in the 21st century since the city is again the place to be seen, to network and to connect. Metropolitan cities are an economic incuba¬tor which is attractive for prosperous firms and entre¬preneurs. Since wealthy individuals or families are not bound to one place, city or nation anymore, they can have multiple residences in multiple of those cities (Beaverstock et al., 2004). A common name for such residences is trophy home. They are newly built spatial houses in city centres or long existing mansions, often on heavily secured fortified estates within the city (Paris, 2013). Their occupancy is occasional, depend¬ing on how many homes the client owns and their (often changing) preferences. These trophy homes are an investment in scarce city ground, as well as sites of luxury 'hyperconsumption' (Paris, 2016).

A project that is very contrasting to the other Big Houses that have been discussed is One Hyde Park, located in London. It can be seen as a trophy home too (see image on the left). It is designed by Rogers Stirk Harbour + Partners and finished construction in 2011. It is the most expensive apartment block ever built (Paris, 2016). While being an apartment the homes can offer almost everything a villa can with the added bonus of the view over the city of London (Partners, 2011). The homes can hardly be discribed as architect-designed private houses, but with it does seem to emerge a new typology of the Big House, namely the penthouse.

The apartments are bought mostly by international investors which causes the most homes to be empty large parts of the year. Today, the purchase of city houses by the global elite, buys not only assets and status, but simultaneously privacy and security in an ever more public city. (Woods, 2016)

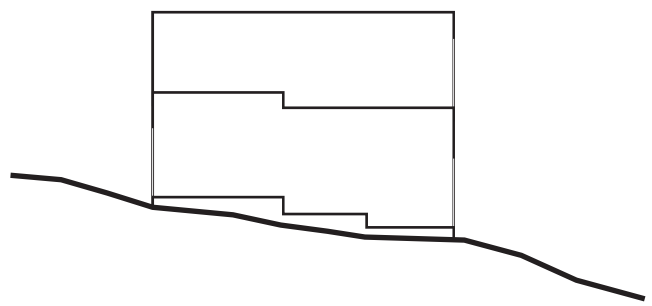




Casa poli is located in a remote location away from the city. It is located on the highest points in the rocky landscape around it, offering a beautiful view over the ocean.

CASE STUDY
CASA POLI

In terms of location, Casa Poli holds quite a unique position within the realm of rural retreats. It is located a mere 45 kilometres from the city of Concepción, the second largest city in Chile. Yet, the peninsula it is located on, is only inhabited by fishermen, who live in a small village North of Casa Poli. Due to the ever-increasing expansion of cities, having a rural retreat within such a short distance of the city is becoming a rarity. Another factor that makes Casa Poli unique as a rural retreat, is the fact that even though it is relatively small and constructed on a limited budget, it enjoys an immense sense of exclusivity in terms of location, as is usually reserved for only the wealthiest of clients. Yet, Casa Poli was constructed for less than 70,000 USD (Lind, 2008). It is located on a cliff with breath-taking views in all directions. There are few other holiday homes in its proximity, due to its difficult position in terms of accessibility and construction.



The previous owner of the plot of land Casa Poli is constructed on, got her hands on the piece of land before Chile's economic boom, meaning that the plot had appreciated in value considerably over the years. Yet, she decided to sell it off for the same price she had bought it for, with the premise that the future owners would do something more meaningful with the land than putting up yet another dime a dozen trophy home, as was practice in the area (Lind, 2008). To fulfil said promise, the architects decided to make the house available as a sort of community centre in the off-season, when they would not be using it.

In terms of dealing with the location, the architects tried to make the building blend in with its surround-ings. All windows that are visible from the path leading to the house are recessed into the wall for almost a metre. This makes them almost invisible when viewing the building. Instead, the house looks like a monolithic piece of rock.

From the inside of the building, the architects dealt with the landscape by placing the users on a podium, just barely above the highest point of the landscape relative to that room. This results in a building that steps down with the slope of the cliff, as can be seen in the image on the left. By lowering the windows to floor level, the podium experience is enhanced.

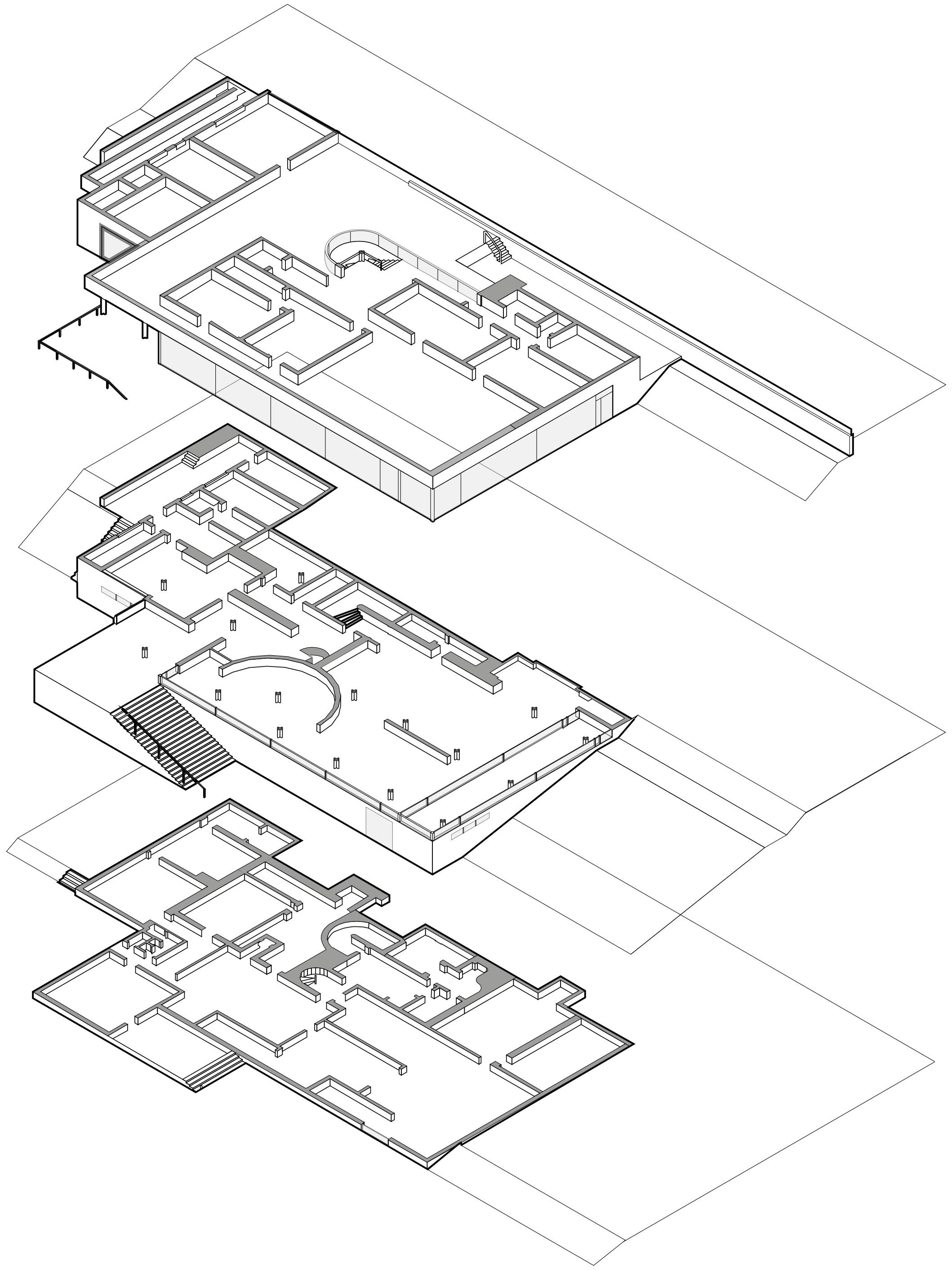
Photo © Brno City Museum's Archive.
Villa Tugendhat by Lugdwig Mies van der Rohe 1928. The house is located in the city of Brno in the Czech Republic. It is located in the middle of the city, with views over a large park.

CASE STUDY VILLA TUGENDHAT

Tugendhat is an Architect-Designed Private house designed by Ludwig Mies van der Rohe in 1929-1930. The house is designed for the couple Fritz and Grete Tugendhat as a family house with their three children, one from Gretes previous marriage and two of them together. Grete was already inspired and impressed by Mies van der Rohe;

"I would often visit the house which Mies van der Rohe built for the art trader Perls, at that time inhab¬ited by the art historian Eduard Fuchs. The house was built in a conventional fashion, however, thanks to the trio of glazed doors the living area was opened up to the garden. It also had a clear division of the various living and dwelling spheres. I had also been greatly impressed by the housing estate in Weissenhof."
(Atelier Zidlicky, 2020).

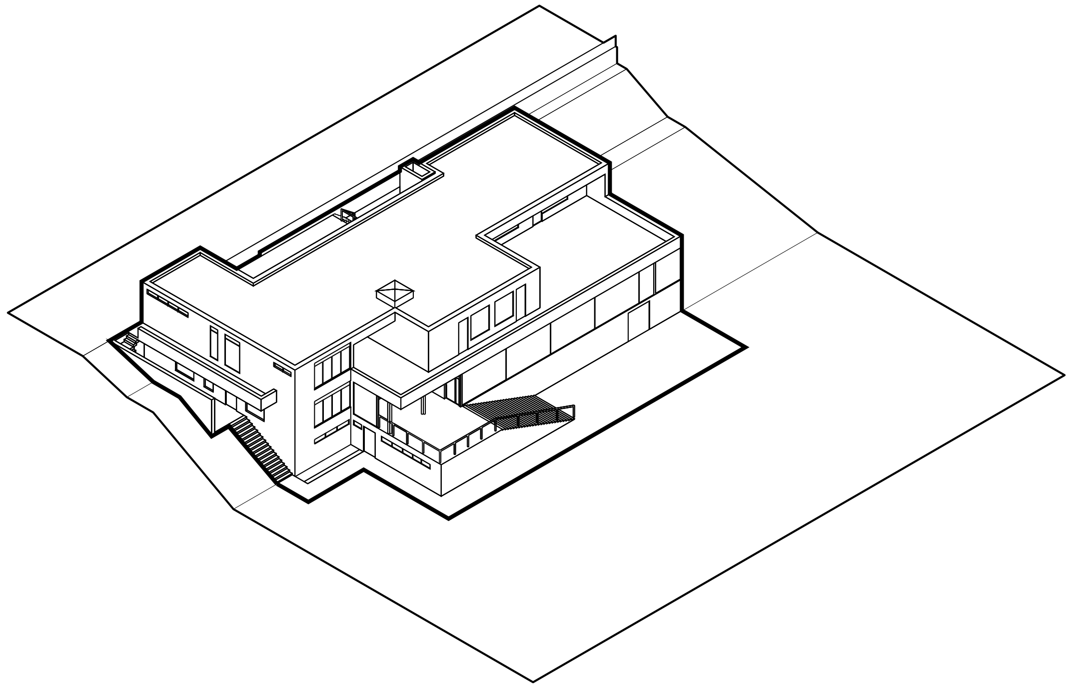
LOCATION & CONTEXT

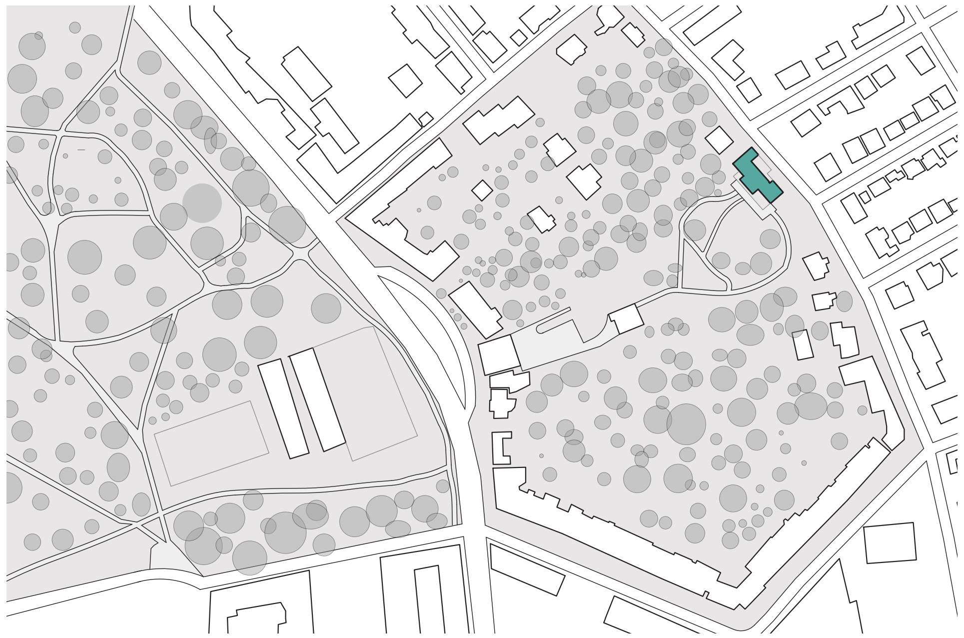


Villa Tugendhat by Lugdwig Mies van der Rohe 1928. The house is located in the city of Brno in the Czech Republic. It is located in the middle of the city, with views over a large park.

CASE STUDY
VILLA TUGENDHAT

Because Grete already knew Mies' other architectural work, she deliberately commissioned him for her house. Grete had a praising opinion on Mies and she therefore gave him unconstrained freedom to design her house. Because of this freedom Mies could experiment further with his architecture and implement this in Tugendhat. However, Grete had another source of inspiration which she wanted Mies to implement; philosopher Romano Guardini. His main philosophy on the perception and experience of space were among others that one needs to provide freedom in space, which only could be done by large spaces. Mies translated this to be spatially implemented into this house





Villa Tugendhat by Lugdwig Mies van der Rohe 1928. The house is located in the city of Brno in the Czech Republic. It is located in the middle of the city, with views over a large park.

CASE STUDY
VILLA TUGENDHAT

The Tugendhat house is a classic example of exuding exclusivity, because of the location in which the villa is situated, Brno, Czech Republic, near the city centre and Lu ánky Park, and of course the choice of Grete to use a 'starchitect'. Tugendhat is located in the area erná Pole and is built in 1928. Erná Pole became one of the most popular residential areas in Brno in the period before the First World War thanks to the offer of both individual and family homes. In this period many private houses were built, the oldest one, the Kaiser Villa, is built in 1860. The villa which is on the same plot as Tugendhat is the Löw-Beer Villa. The Löw-Beer Villa is built around 1903-1904, Grete's Father, Alfred Löw-Beer, purchased this plot of land in 1913 and, after the marriage of Grete and Fritz Tugendhat, gave the upper part of the plot to Grete as a gift to build a house for her family and financed the construction of the house.

In contrast to the exclusivity of the villa, the north-east facade where the entrance to the house is located, does not have this exclusive appearance at first impression. This is because the house is built on a slope, so a passant only sees the top floor. By experiencing the building itself and moving through it, the house becomes more luxurious step by step. It takes you to the living room on the second floor where the big glass façade gives you a beautiful view of the garden which blends in with the park.

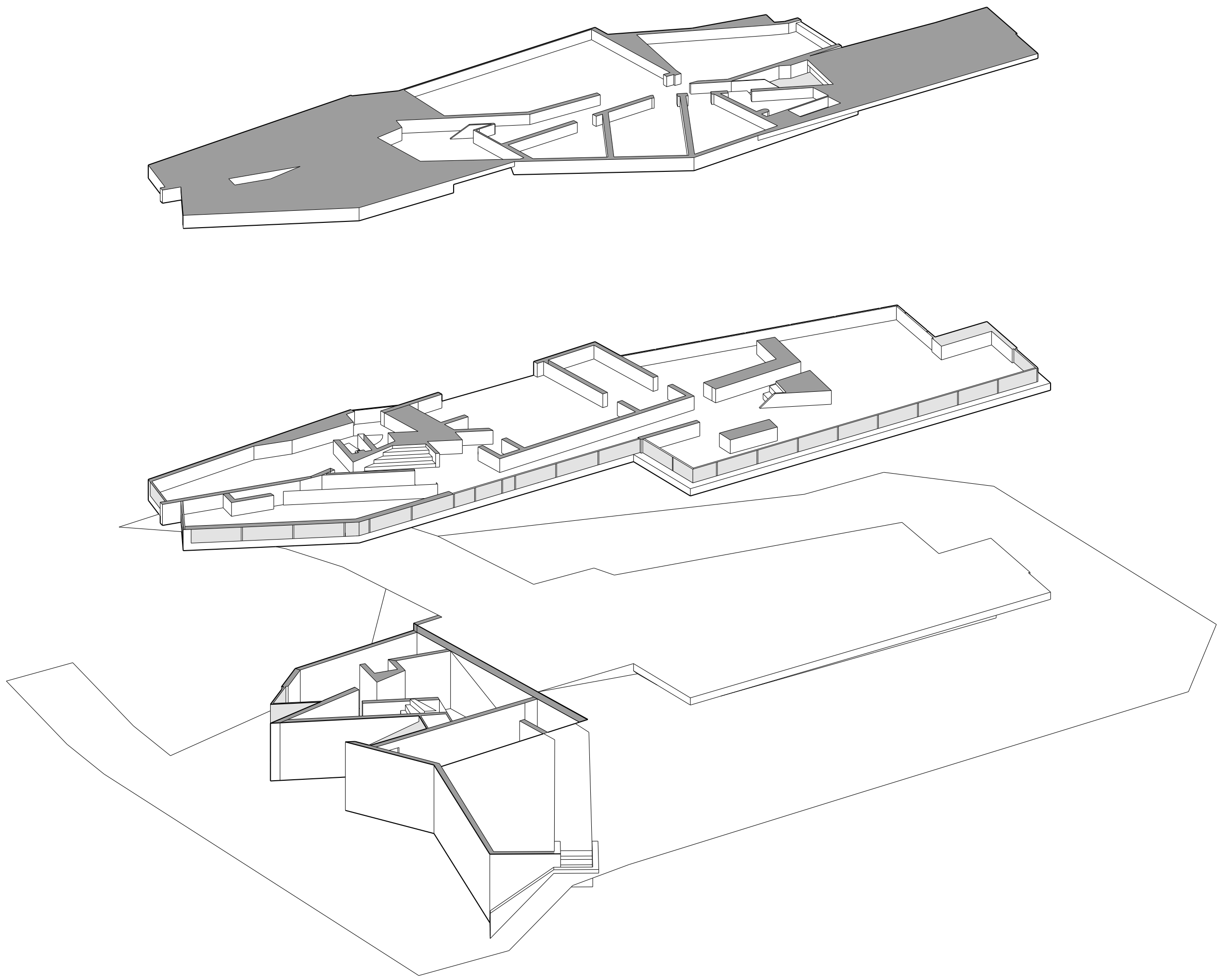
Photo © Christian Richters.
On the picture, Möbius House by UN Studio is depicted. The house is located in the exclusive area 't Gooi in the Netherlands, where many large private houses are located. The attraction to this area is most likely the rural character and the space, while the area itself is close to most major cities.

CASE STUDY MOBIUS HOUSE

The Möbius House is a single-family private house that was designed in 1998 by the European architecture firm UNStudio (Ben van Berkel and Caroline Bos). The house is designed for a family who would like to remain anonymous.

The design of the Möbius house is a direct response to the clients' request to design a family home. important aspects in this are the flows of their work and family life. Another important feature is the surround¬ing natural landscape that the clients integrated, a wish was that the family house would respond to its immediate surroundings. This eventually resulted in a very tailor-made family home.

LOCATION & CONTEXT



Villa Tugendhat by Lugdwig Mies van der Rohe 1928. The house is located in the city of Brno in the Czech Republic. It is located in the middle of the city, with views over a large park.

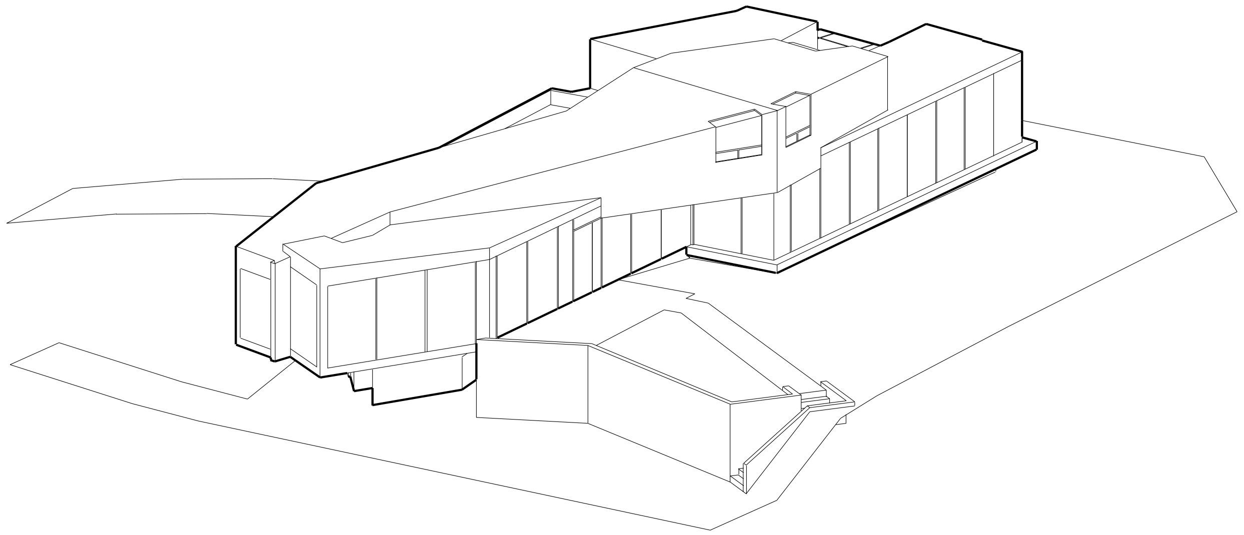
CASE STUDY MOBIUS HOUSE

"A kaleidoscopic fusion of the landscape and the house. The intertwining trajectory of the loop relates to the 24-hour living and working cycle of the family. As the loop inverts, the exterior concrete shell trans¬forms into interior furniture and the glass facades become internal partitions"
(UNStudio, 2005).

The mobius strip on which the house is based shows the orga¬nization of two intertwined routes, it shows how two people can live together, but on the other hand also separately. The shared spaces in the strip are the points where they meet. The client's wish is clearly reflected here where the idea of two entities leading their own pathways but sharing certain moments, together in one family house (World-architects.com, n.d.).

"You could never hide yourself in these places in Mies's Farnsworth house, for example. That was a mis¬take of Modernism. People need places to hide from each other, too. You need everything."
(van Berkel, n.d.)

In the quote above, van Berkel criticized the prin¬ciple of modernism, the open floor plan. At the Farn¬sworth house of Mies van der Rohe it is difficult to find a privacy place within the house. This is because there is no strict separation in rooms, only visual sep¬arations. Van Berkel states that everyone should have their own place where you can retreat. That public and private can be separated.



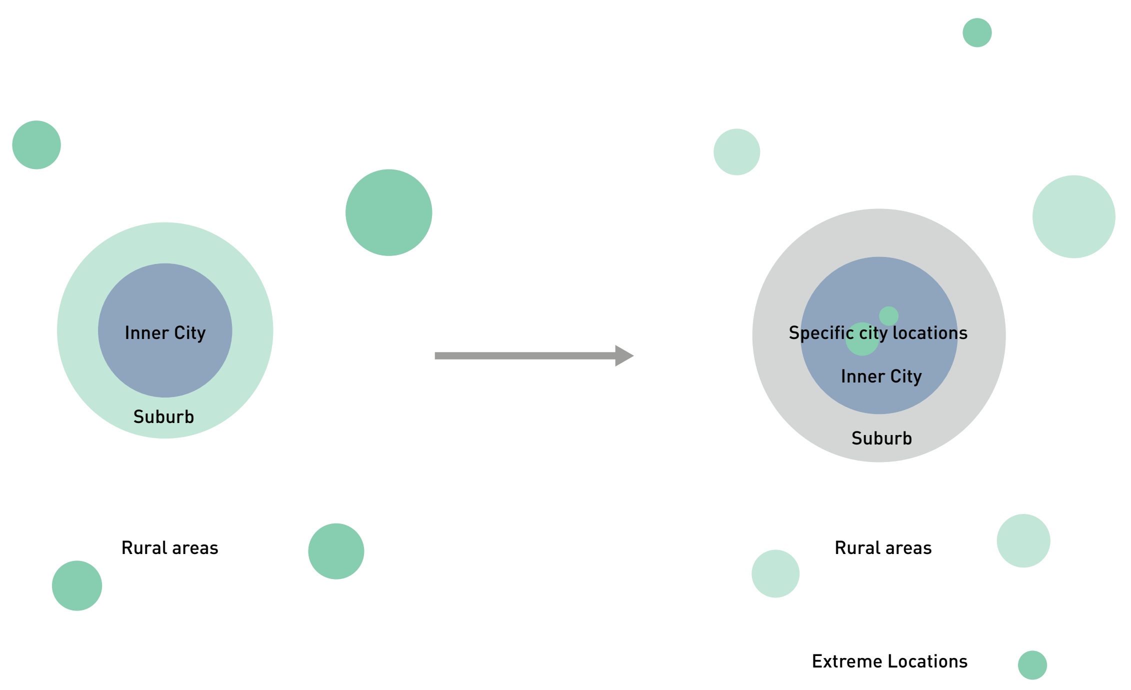
Villa Tugendhat by Lugdwig Mies van der Rohe 1928. The house is located in the city of Brno in the Czech Republic. It is located in the middle of the city, with views over a large park.

CASE STUDY
MOBIUS HOUSE

The Möbius House, located in "Het Gooi", a green residential area between Amsterdam and Hilversum, with a series of detached houses surrounded by woods, meadows and heath land,. The curved and angled lines of the spatial loop of the Mobius strip reflect the varied landscape, while the glazed surfaces interact with the spectacular natural surroundings (Floornature, 2014).

The Möbius house is located in a wooded area. Reflectivity of mixing the Mobius house in the envi¬ronment is an important aspect in the design. The landscape has been used as an extension of the inte¬rior, which also indicates the unity of the interior and exterior. The low height and the use of the shape of the Mobius strip shape also symbolized the infinity and absence of inside and outside.

Also the outdoor wooded area is one of the first essential relationship related to the building and its location. There is a game between interior and exte¬rior and natural and artificial. This is reflected in the building by the use of the concrete closed parts in con¬trast to the transparent glass facades. If we look at the building from the outside, it can be concluded that the reflection of the glass can accentuate the impressions of the surrounding forest. The glazed facades take over the colour and structure of the landscape and visually dissolve the building in the landscape. How¬ever, at night the opposite is true. The interior lighting of the house has the effect of creating the idea that the building is visually enclosed and isolated in the dark¬ness of the landscape (McGie, 2009).



CONCLUSION

EXCLUSIVITY

Clients of architecturally designed private houses have hardly been affected by urbanization and densifi-cation. They can buy their privacy by physically sepa¬rating themselves from society. This trend has a long history and is therefore likely to continue in the future.

Many of the architecturally designed private houses are located outside of the city. This has to do with the availability of space in rural areas, the freedom to exhibit or enjoy a particular lifestyle and the beforementioned exclusive culture. These locations go beyond the conventional suburb, as suburbs no longer reflect the demand of upper classes. An example of this is the Möbius House. Located in the renowned area called ''t Gooi', the house defines upper class exclusivity. 't Gooi is best known for its luxurious villas which are home to many Dutch TV-personalities. The beautiful location is therefore associated with prestige and esteem. To live here, is to be part of this elite.

EXTREME LOCATIONS

The locations of upper class residences go beyond suburbanisation to rural and more and more extreme locations as illustrated on the left. Often, sites with particular assets within the landscape are sought to distinguish oneself from others. Maison à Bordeaux is an example where such as asset is utilized. A hillside just outside of the city provides the optimal location for privacy and exclusivity. The hill, along with the orientation of the building provide a panoramic view over the city of Bordeaux. A result of going beyond the conventional rural retreats is the Poli House. Here, the extreme location of a coastal cliff was chosen. This exceptional site is a literal separation from soci¬ety since only a few buildings in a village are nearby. This causes breath-taking views for miles away, in all directions.

THE CITY AS A LOCATION

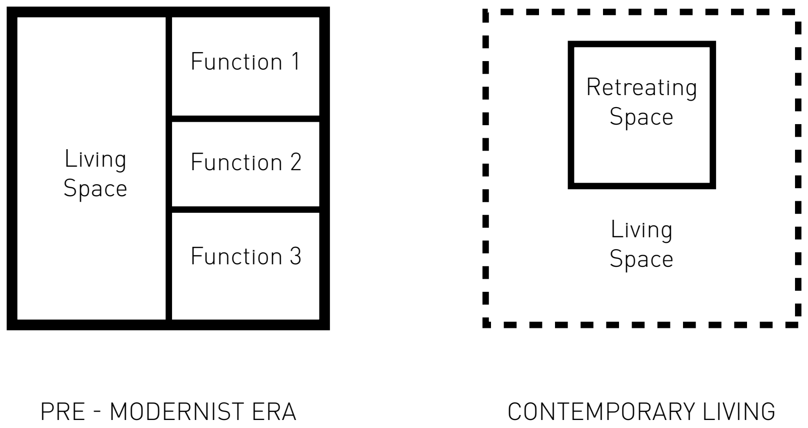
A more recent trend in location for housing is the re-appreciation for the city as a residential area. Because of the improved liveability in the cities and wider range of housing types, it can now utilize its full potential as a place to life, network and connect. And since wealthy individuals or families are not bound to one place, city or nation anymore, they can have mul¬tiple residences in multiple metropolitan cities. These residences are most often long existing mansions on estates within the city and are referred to as trophy homes. One of such trophy homes is villa Tugendhat. It was also originally built on the outskirts of the city. But with the expansion of Brno, the house now resides within boundaries of the city.

Photo © Eva Bloem
Möbius House by UN Studio 1998

INTRODUCTION

Space, as a notion within the English language, was only introduced to the architectural vocabulary following the emigration of German architects to the USA and Britain, just before World War Two (Forty, 2004). Ever since, the realm of architecture has been obsessed with the concept, exempt a brief period when Post-Modernists subjected its importance to that of 'place' (Üngür, 2011). Before that, in the 1920s and 1930s, the Modern masters were already philoso¬phissing about, and giving importance to the concept, while using an extensive array of terms to talk about the notion of space (van de Ven & Wang, 1978). Even when The International Style was written for MOMA, the word space was not used. Instead, the old notion of 'volume' was used to talk about what presently is seen as the overarching concept of space (Üngür, 2011). Nowadays, the notion of architecture is often defined as a combination of space and form, where the form encapsulates the space. Making both con¬cepts indispensable when discussing architecture, and thus making them indispensable when discuss¬ing contemporary and future trends within architec¬ture. Use, as a concept within architecture is directly related to the concept of space. However, the use is more closely related to a societal context, where space is more closely related to an architectural context. In this chapter both will be discussed, as trends within the use of Big House design are thus closely related to trends in space.

To address the topics of space and form, we will look at trends in the division of spaces; both in the interior divisions as well as the division between inside and outside. We will look at how trends within the use of the house might be the related of the trends in spa¬tial divisions. We will look at how spaces are ordered by means of the space syntax as an analysis tool, and we will look at the old concepts of Raumplan and Plan Libre, to see how they might have held up.



Layout of houses in pre-modernist era versus contemporary times.

DIVISION OF SPACE

DISPERSION OF FUNCTIONS

The very first houses to have ever existed, consisted of only one room. The only division that was needed was that between man and animals (Melhuish, 2000). It was only when the required space was getting bigger, and the lack of advanced construction techniques made it impossible to accommodate this growth in a single space, that shelter had to be divided into separate spaces. Yet, these spaces remained largely open to one another. It seems that it is in fact the specialisation and formalisation of activities inside the houses of the West that caused them to be broken down into smaller units with very specific functions (Melhuish, 2000).

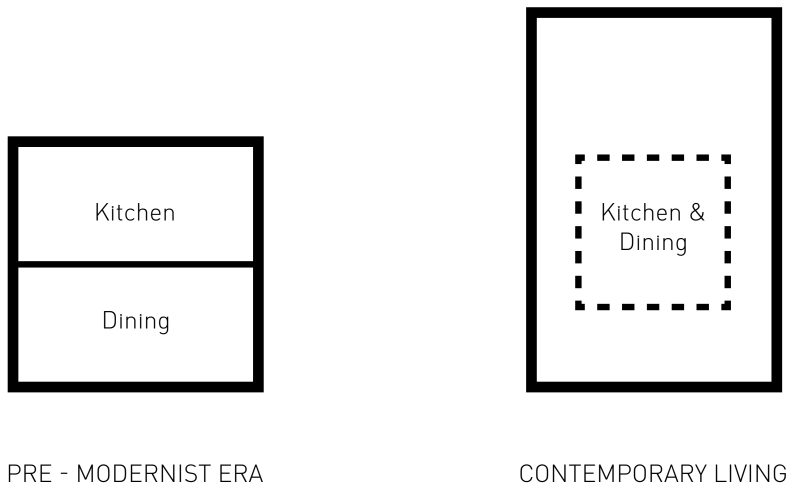
MERGING OF FUNCTIONS

This trend, however, is relatively short-lived . One of the most impactful changes in western cultures is the decrease in separation between functions. Already in the early 20th century, the Modernists started questioning the subdividing of the many different activities into small units within a larger whole. Nowadays, many different rooms, such as the library, the gentleman's room and the ladies room have all been absorbed into one single space (Krisch, 2013). This shows that a necessity for reduced floor area has started to emerge, as well as a strong decrease in formality in our day-to-day lives (Krisch, 2013).

The foundation for these 'open' plans can be traced back to the Modern masters such as Mies van der Rohe, who proposed spaces with only a minimum of physical divisions, to step away from historic social structures (Ostwald & Dawes, 2018). However, since these functional divisions have been ingrained in the way we have lived for the past centuries, a total abandonment of separation walls is still seen as far too progressive for most people. Yet, especially among younger generations who often comprise of single-person households, loft-living over the last decades has been increasingly seen as a perfectly acceptable type of dwelling (Hamnett, 2009).

NEED FOR RETREATING SPACE

Households with more than one person, however, do seem to require space for retreating within the house (Melhuish, 2000). This is due to the increasingly individual lifestyles and schedules of the individuals within each household (Krisch, 2013), which is being enabled and supported by the rise of the internet and domestic technologies. These individual rooms there¬fore become miniature homes within the house, which will become increasingly important in the future of housing. This development is illustrated on the left. We see that houses before the 20th century used to be internally separated based on functions, whereas now we see that this separation is more so aimed at separating individuals. A reason that might have contributed to this development might be found in the fact that it has become the norm to heat all rooms in the house, rather than just the living room, which used to be the main room where most time was spent (Livingstone, 1992). This provides the individuals within a household a valuable reason to retreat to another space without exercising the exact function that space was specified for, but rather use it for the privacy it offers.



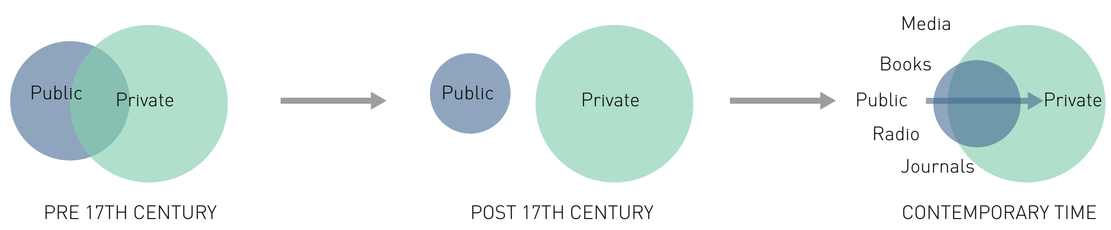
Role of the kitchen in pre-modernist era versus contemporary times.

INTERIOR FUNCTIONS

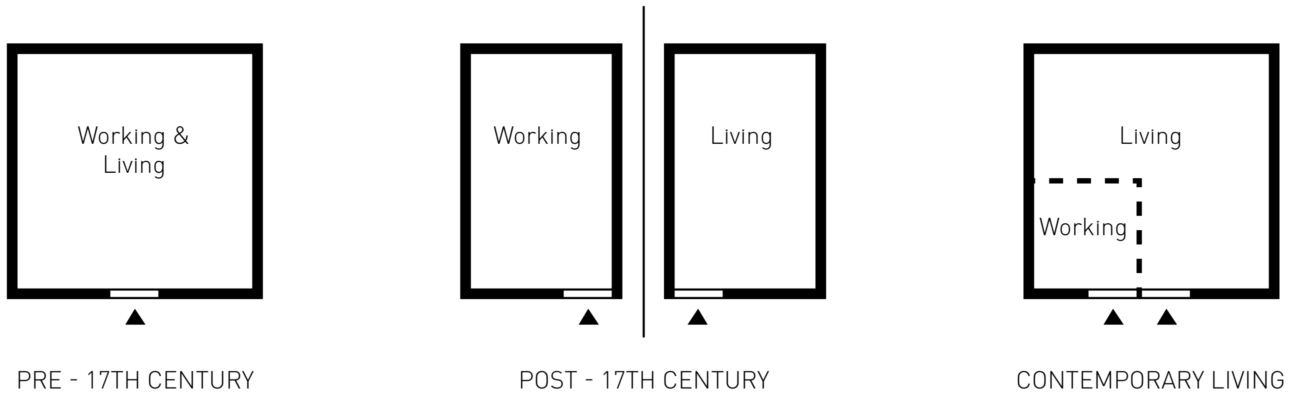
Next to the increasing importance of the personal room there are other changes in the significance and role of different functions within the house. An example can be found in the once so important separation of (domestic) work and leisure. Eating in the kitchen for example had been unpopular for a long time, up until rather recently (Krisch, 2013). Nowadays, there are even indications that the kitchen will become the centre of the house again. Domestic labour is distributed more over the members of the family, as in the society, and the kitchen is the central hub of all house work and is thus able to transform in the central meeting place of the household again (Krisch, 2013). These changes are illustrated on the left, where a clear distinction is visible before the 20th century, and a complete merger between kitchen and dining is the standard nowadays, and has been for the last few decades.

There is a noticeable trend in the importance of the bathroom as well. Where the bathroom used to be small and pushed to the corners of the envelope, with the growing awareness of personal hygiene the bathroom became an actor of luxury and increased in size and number (Krisch, 2013).

THE FUTURE OF THE BIG HOUSE
USE & SPACE



The evolution of the notions of public and private in residences.



The evolution of working and living in residences.

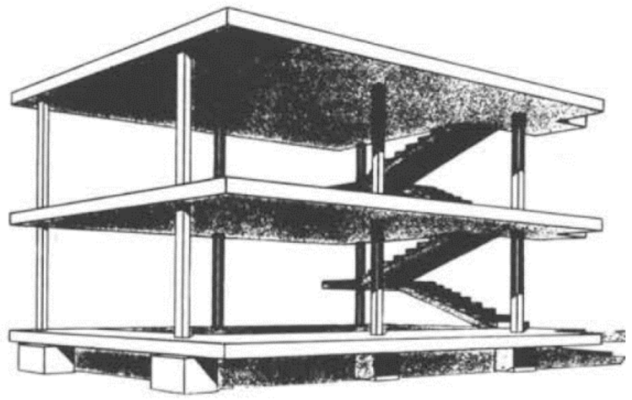
DIVISION OF SPACE

PUBLIC VS PRIVATE

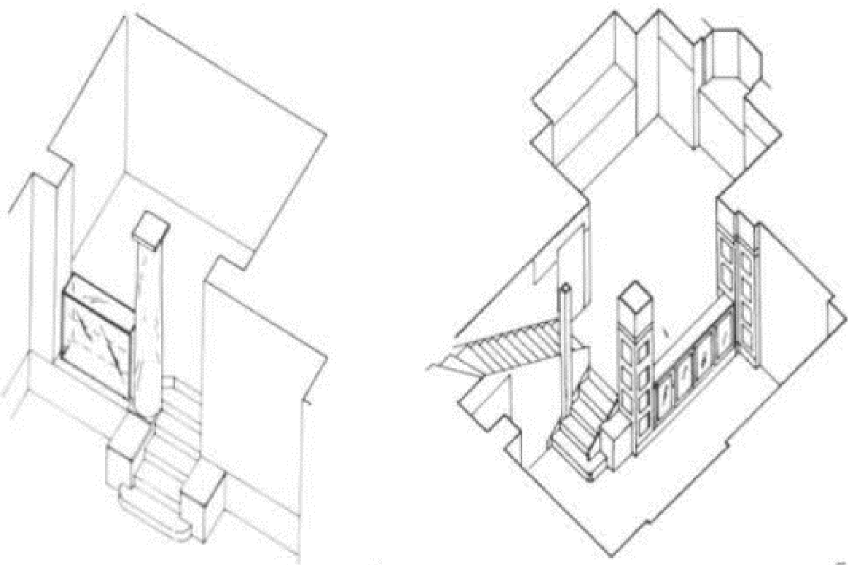
Another important development in the separation of spaces, is the one between inside and outside space. In the beginning of the 20th century, an important change took place in the relation between the public and the private. From the emergence of the private house in the 17th century, until the 1920s, the level of privacy within the private homes grew as the presence of the public decreased (Riley, 2017). Then with the introduction of the radio, and an increased interest in other media such as books, journals and magazines, the public aspect was once again introduced to the pri¬vate house. The presence of media grew, as technology advanced, and with it grew the presence of the public in the private house. This development is illustrated in the upper image on the left. Due to that development, the need for our private homes to be truly private diminished, which resulted in trends such as the application of larger windows. As a result, the need for a retreating space became all the more important. The private areas of the house become more private, while the public functions become public, to a point where it can even be shared with others or the community.

WORKING AND LIVING

This erosion of separating different functions and daily activities continues and with the coming of modern technology, it even goes beyond the borders of 'the domestic'. Broad availability of both the home computer and access to internet opened the possibility for working from home and for the first time since the industrial revolution the distinction between working and living is fading (Melhuish, 2000) (Rowe & Kan, 2014). Said development is closely related to that of how is dealt with public and private within a home, and is illustrated in the lower image on the left.



(Risselada et al., 1988)
Plan Libre, as conceived by Le Corbusier



(Risselada et al., 1988)
Raumplan, as conceived by Adolf Loos

ORDERING OF SPACE

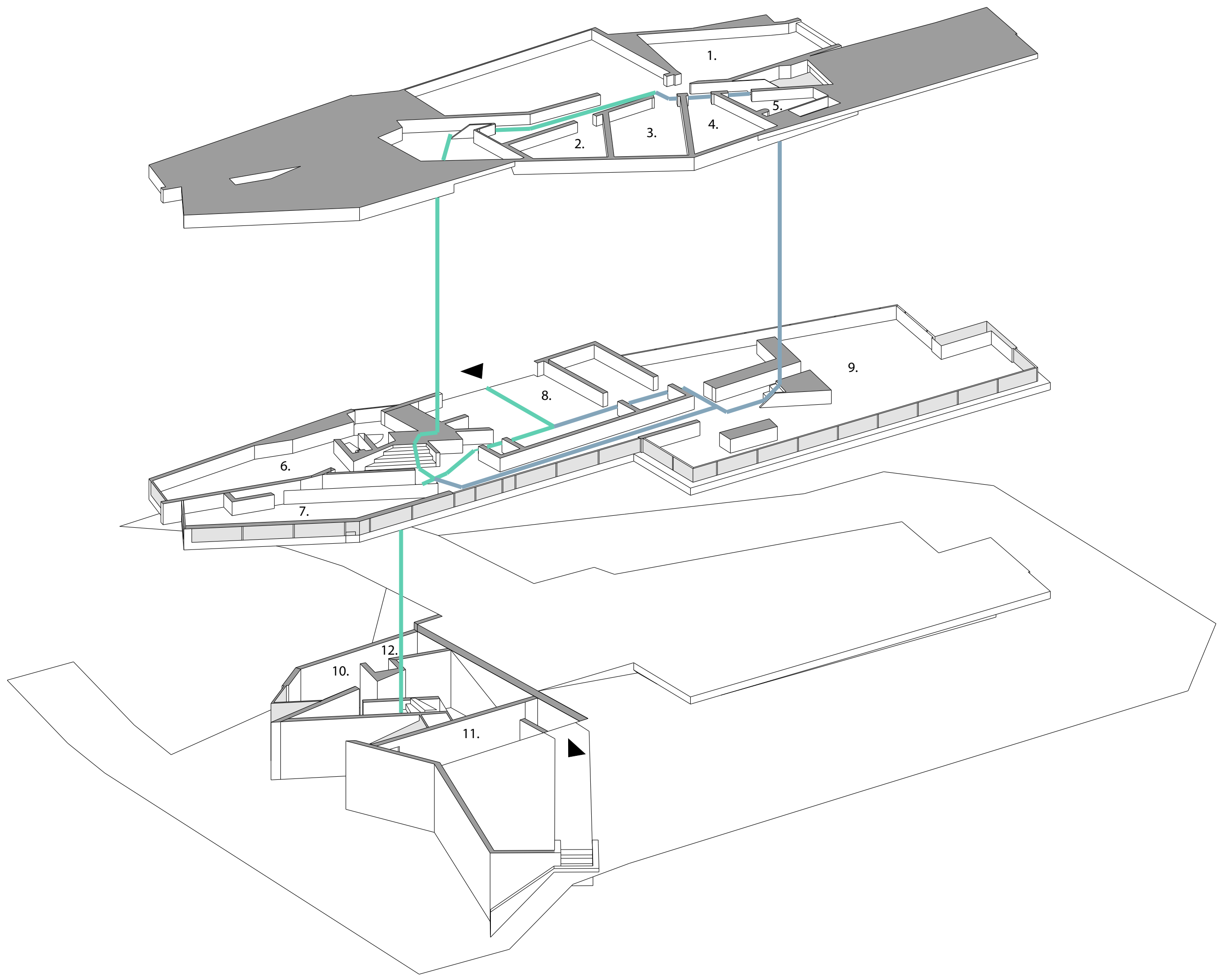
In architect designed private houses the personality of both the client and the architect is stronger than in other building types (Rapoport, 1969), and because of growing individuality and pluralistic lifestyles it is hard to predict how housing needs in terms of use and space will change in the future (Jonuschat, 2012). Still, lifestyle is subject to culture and thus we can see trends and fashion in the architect designed private house too (Rapoport, 1998). As the basic program of a house stayed almost the same in the last 50 years (Schittich, 2013), the ordering and priority of the spaces and functions within and around the house thus become the point of interest. Observing trends in how spaces and functions are ordered within a building is very difficult, as these are thus very dependent on the wishes of the architect and the client. Instead, we will look at how two historic notions on how to organise space are holding up in contemporary architecture, and to what extent they might have had an influence in our case studies.

RAUMPLAN VS PLAN LIBRE AS A WAY OF ORGANISING SPACE

One of the Modern masters who concerned him¬self greatly with the concept of space, was Adolf Loos. For Loos, the notion of space was the most important aspect in a design. More so than the exterior of a building. Loos ordered his space using what he called the Raumplan, whereas his contemporaries were more focussed on the Plan Libre (Risselada et al., 1988). In the Raumplan, Loos organised the space not just in a floor plan, but rather in three dimensions. This means in essence that his spaces are interlocking and pen-etrating each other in three dimensions (Heathcote, 2000). Moving through these spaces thus becomes a very orchestrated experience, with many changes in both elevations and in floor-to-ceiling heights. For his contemporaries, such as Le Corbusier, the ordering of space is a much less orchestrated experience. To him, the ability to freely move through space by making use of a standardised system would result in strong, coherent architecture (Risselada et al., 1988).

RAUMPLAN AND PLAN LIBRE IN CONTEMPORARY ARCHITECTURE

Nowadays, the principles of Le Corbusier are widely adopted by the building industry. Especially larger buildings make use of a post-beam structure, where load-bearing interior walls are no longer needed. Allowing for more flexibility within the building. In private house design, however, various adaptations and evolved versions of both Plan Libre and Raumplan seem to still coexist harmoniously, as the approach is far more dependent on the individualistic desires and needs of the client, and the way of practicing design of the architect.



Routing in the Möbius house.

CASE STUDY
MOBIUS HOUSE

''The Möbius house is based upon the concept of the Möbius strip, it is usually demonstrated as a loop of material with a half twist resulting in a surface with only one continuous side, It has become a puzzling and paradoxical three-dimensional form with no inside or outside. As such, the Möbius house is conceptualized on the notion of a continuous and fluid circulation between social space, private space, and paths of movement which are subsequently defined by ambigu¬ous boundary conditions''

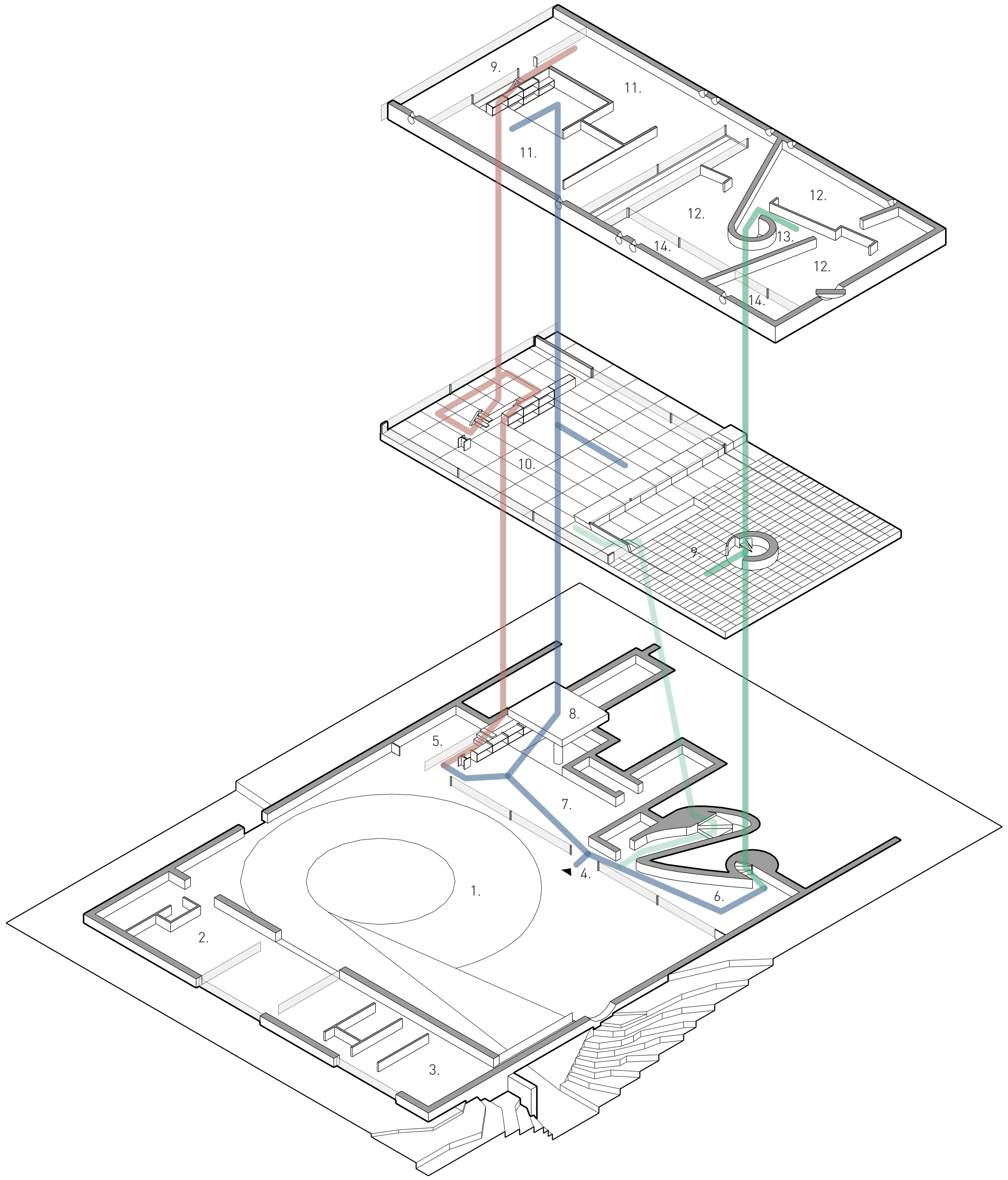
(UNStudio, 2005).

The mathematical model of the Möbius strip was not literally conveyed in the design of the Möbius house. The model has been conceptualized or thema¬tized at various points, this is reflected in architectural elements, including the use of light, the different stairs and the way people move through the house (routing).

The diagram is incorporated into the building in a mutated manner, introducing the aspects of duration and trajectory (World-architects.com, n.d.).

The crystalline angular shapes of the house extend into the wooded area - so much so that when standing in a room, it is difficult to determine whether adjacent spaces are internal circulation or penetrating fingers of outdoor spaces. This is partly due to the extensive use of top lighting and the use of exposed concrete for both interior and exterior wall surfaces (Croft, 2004).

The interior of the Möbius house is an exercise in spatially complex relationships and connections. Although the modest program consists of basic living conditions including living room, bedroom and kitchen, the Möbius house also has two independent studios. These two studios should be seen as two separate spaces for which there are two separate circulations that sometimes run parallel in a shared journey through the succession of spaces. In this way, public and private are separated as much as possible. The Möbius strip concept has been applied here as a con¬cept that ensures that when routing through the house there is a separation between the private life of the resident and the business life, without these routes having to cross each other (UNStudio, 2005).



Routing in maison a bordeaux.

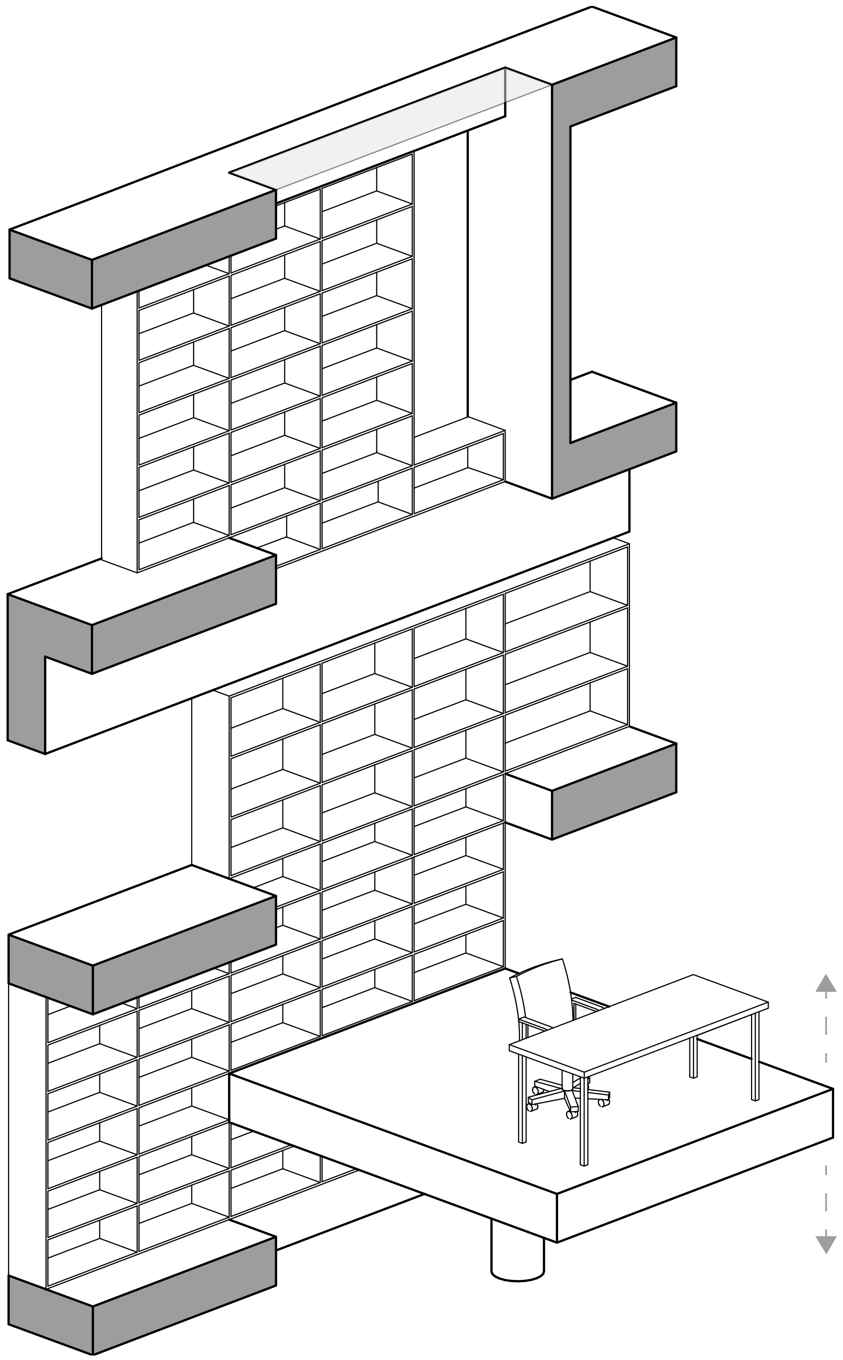
CASE STUDY
MAISON A BORDEAUX

One of the most remarkable things in its design is that the house consists of actually three houses stacked on top of one other. For a residence being designed for someone bound to a wheelchair, this might not be the first thing popping up in one's mind. All of the floors characterize themselves by their own unique spatial conditions (Melhuish, 2000). For all three floors the architect got inspired by different projects, resulting in three layers of completely different architectural features.

Vertically, these volumes are primarily joined by an element which forms the heart of the building. An elevator platform enables the husband to move to each of the floors. With the inclusion of the elevator platform, Rem Koolhaas seems to refer to Le Corbusier's 'a machine for living' (Melhuish, 2000). It embraces this principal in literal terms by the platform being an actual machine, enabling the husband to move throughout the residence. Therewithal, it finds its way in what the essence of Le Corbusier's statement covers. The principle of the elevator is to fulfil the requirements of the restricted movability of the hus¬band, in order to enable him living a comfortable life. A house is said to help for all necessities of life, so does the design by OMA dedicating itself to the changed life conditions of Jean-Francois.

The volumes can be distinguished according to their appearance. The lower floor is partly excavated into the hill and features cave-like spaces on that end. The middle floor is completely transparent while being fully glazed in order to provide a view on the city of Bordeaux. The top floor is contrastingly more solid, facilitating the baths and bedrooms. The building is divided in two vertical sectors, while the upper floor consists of two independent parts. One part for the parents and the other for the children, both being accessible by their own vertical access.

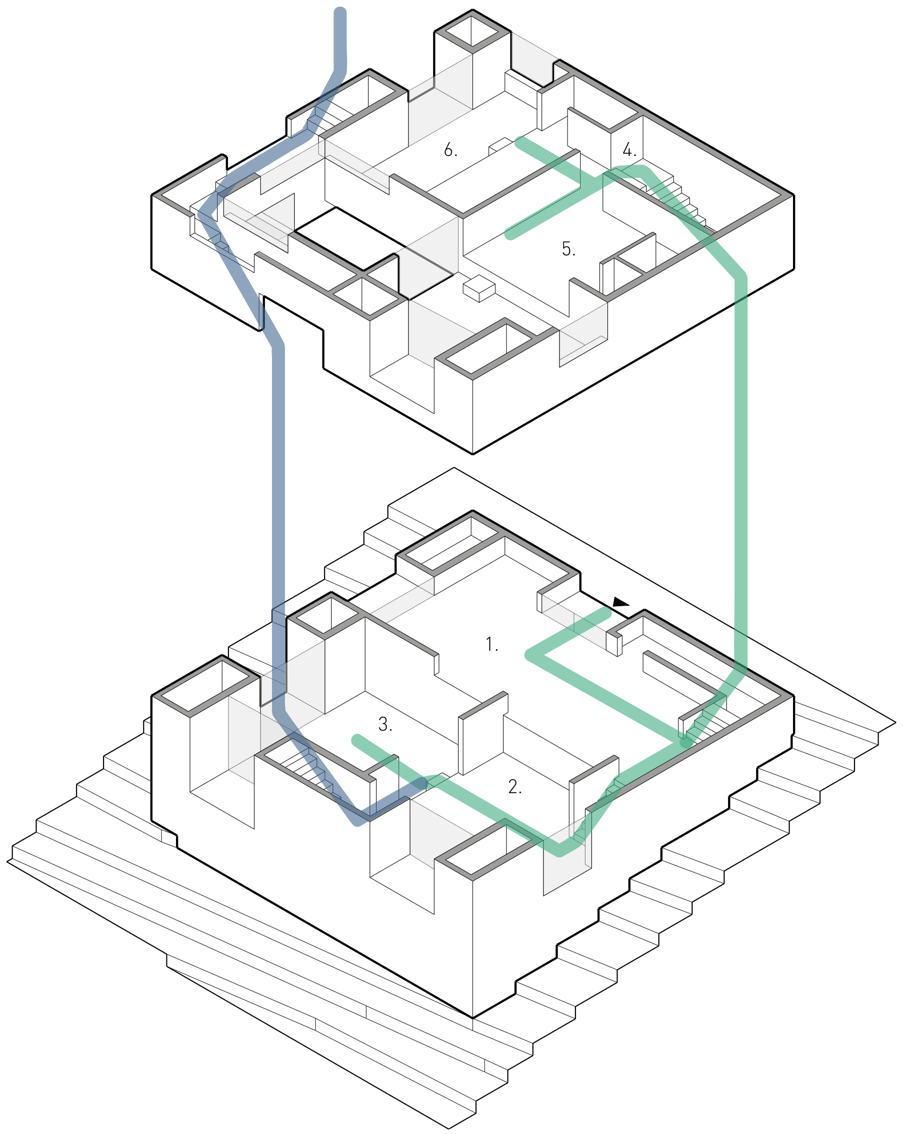
The lower floor houses its functions carved into the hill. Spaces merge in front of the large glass façade which overlooks the semi-buried courtyard where the main entrance of the house is located. On the far end of the courtyard there are two other units. One meant for guests and the other for the caretaker. The middle floor is where the inhabitants would spend during daytime. It is fully glazed which seems to merge interior and exterior. Sliding walls on both floors allow the res¬idents to open towards the courtyard on the lower floor and open towards the outside terrace on the middle floor. The top floor, as mentioned before, is divided into two parts. This volume as a whole is a concrete box, allowing views through small portholes. The latter are placed carefully in order to offer interesting views over the surroundings of the house (WikiArquitectura, 2014). The upper level's box appears to enclose one volume, while in reality it is split up in two. Koolhaas created a narrow space in between, which allows nat¬ural light to enter both units of the upper floor.



The elevator platform in maison a bordeaux that doubles as the owner's office.

CASE STUDY
MAISON A BORDEAUX

Spatially the elevator plays an important role. The volumes of the house are in general relatively simple, but organized in a spatially complex way. As mentioned before, all three volumes are expressing different conditions. The elevator can be considered the spine of the spatial layout of the house. As a 3 x 3,5 meter floor area, it is masked by being office space. Due to its movement, both the spatial experience of the house as a whole and the platform itself are continu¬ously changing (Craven, 2019). Either the presence or absence of the dynamic platform on a particular level, change the architecture of it. One end of the elevator is on every floor enclosed by polycarbonate bookshelves, as extruding the office in vertical direction. The move¬ment of the elevator therefore allows the husband to easily reach any part of it.

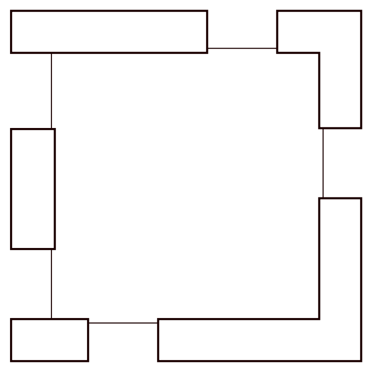


Routing in casa poli.

CASE STUDY
CASA POLI

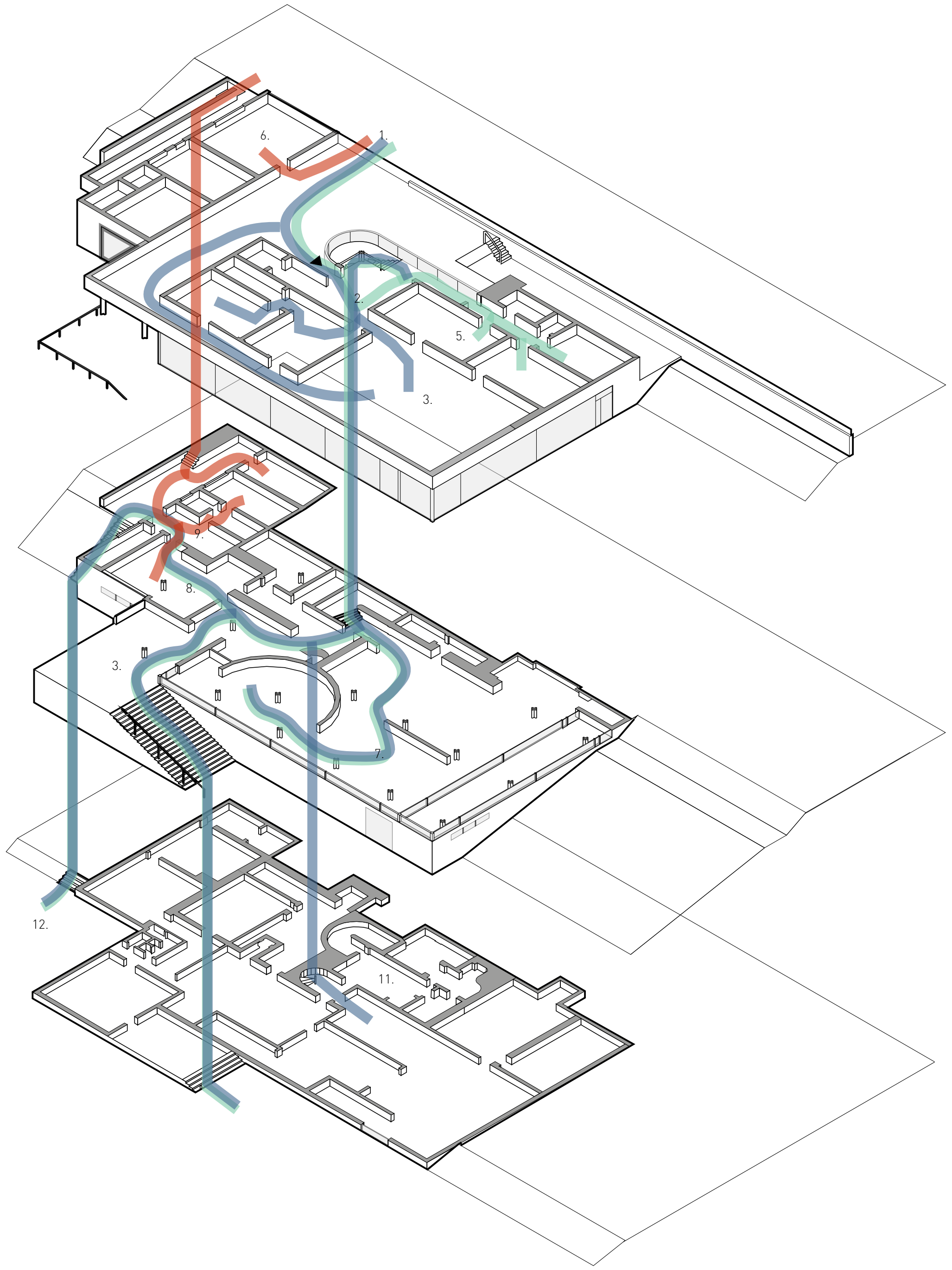
Casa Poli offers a unique program, that resulted in a very strong concept. To be able to offer a house that feels both domestic, while also fuelling the creativity and serving the community, the architects introduced a concept where the house would be defined by its interconnectedness between the various spaces on the inside. Initially, the house was not even designed with specific functions prescribed to each individual space, but rather, a series of rooms with varying degrees of connection to one another. That way, the intended flexibility could be maintained most optimally.

The plans for Poli House are in essence very simple. There are two floors, which each measure about ten metres by ten metres. All storage, bathroom, kitchen and circulation spaces are tucked into the perimeter, which appears as very thick walls, which in reality are thus hollow, as is illustrated below. Instead of leaving the resulting interior space empty and flexi¬ble, however, the architects chose a derivative of the Raumplan approach to have more control over the outcome of the connectedness of the different rooms, as to adhere to their main concept as closely as possible.



The Poli house is in theory of a moderate size. How¬ever, as can be observed in exploded view, the archi-tects chose to sacrifice quite the amount of floor area to achieve the varying degrees of connection between the different spaces. Floor area as well as freedom of movement was sacrificed to maintain a strong concept. Rooms often flow into one another, meaning there is a visual connection, without an opportunity to physically move into the other room due to the difference in height. A concept that can also be observed in Loos' Villa Muller, which is designed as a Raumplan.

The most important space of Casa Poli is the living & study room. In essence, this is the creative space. It is the space where the linear circulation of the ground floor is ter¬minated. It offers a physical and / or visual connection to all other important spaces in the house. It even provides visual connection to the bedrooms, through the void, that renders the creative room almost seven metres high. The creative room is the most connected room in the house within that hierarchy of different levels of connectedness, and is thus the as a space the climax of Casa Poli.



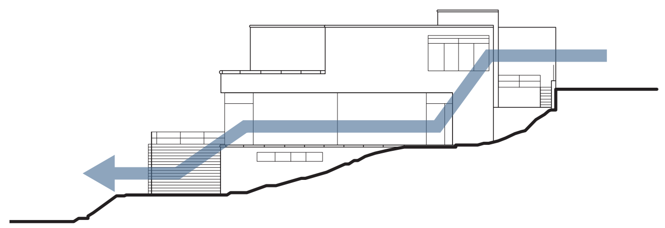
Routing in villa Tugendhat.

CASE STUDY
VILLA TUGENDHAT

Romano Guardini, a philosopher who was a sig¬nificant figure of German Christian Personalism, had ideas which gave inspiration to Grete Tugendhat and was thereby influenced into the space of the Tugendhat house:

"Large spaces provide freedom. Space has a completely special calm in its rhythm which cannot be provided by a closed room"
(Atelier Zidlicky, 2020).

This is why the living area is designed in a way that the floorplan is open. Mies had met Guardini, the Tugendhats were aware of his work, they discussed together his views. During the design of The Tugendhat Villa, Guardini's work state that "a well-built inter¬nal space has levels which lead into depths" (Atelier Zidlicky, 2020). This is precisely the way the space of the Tugendhat Villa works, entering downwards into the spaces.



The Villa is divided into three floors, the top floor is where you enter the house and where the bed-, and bathrooms for parents and children are located. The first floor is the main floor, because of Mies's choices on structure, he has been able to create a large open and bright space. The library is integrated in the living room. Further on this floor are the servant rooms and the kitchen. The basement is serving entirely for the technical aspects of the Villa. For more clarity,

The image on the left shows that there is no clear route that one should follow in the horizontal way of sense, and that there is no strong hierarchy visible in the building.. Vertically the route is very clear, one enters the house on the top level and there is only one highly visible stair that takes you to the main floor. The space syntax shows also the relationship between the social patterns of the Tugendhat family and the spaces, from every floor there is a way to enter the garden, one can conclude that, in this case, the boundary between inte¬rior and exterior is thin, which is. The living space with the large windows is indeed a space with the philoso¬phy of this, merging the inside with outside. However, there are different routes to follow for different users; the blue lines in the routing diagram is meant as the main line, especially for the parents, the green route is for the children and the orange route is for the ser¬vants and the chauffeur.

Villa Tugendhat interior (Atelier Zidlicky, 2020)

CONCLUSION

PUBLIC VS PRIVATE

An important development that can be observed in private house design in the context of space, is the fading of the line between public and private. At some point in the 17th century, when houses for the middle class started becoming truly private, the public was increasingly banished from these houses. At the same time, the formalisation and specialisation of functions made for more interior divisions, which were thus aimed at separation of functions, and not so much on the separation of people. The last couple of decades, however, the presence of the public in the private house has been increasing, which means that the hard line between the inside and the outside is fading. On the same time, interior separation walls are becoming less, and are more focussed on separating the individuals, rather than the functions, to give them a private place where they can retreat .

WORKING AND LIVING

This trend has been ongoing for quite a while, but a new trend appeared, which also emerged from the rapid technological advancements of the last decades. This new trend is the combining of working and living within the same home. The very development that gave us the concept of the private home as we know it today, is starting to reverse. More and more homes are being used as the primary or secondary source of generating wealth. An exemplary development can be observed in Maison a Bordeaux. The elevator, which functions as essentially the most important space for the owner, is also his home office. It can be expected that this trend will continue, and even grow bigger due to the 2020 pandemic that forces many people to work from their homes.

TAILORING SPACE

It should be noted, however, that all cultural and societal developments should be observed in the light of the individual, as it is currently the time of diversity of lifestyle and pluralism (Rowe & Kan, 2014). This also comes down to not taking the trends and observations in this chapter as being carved-in-stone truths, but rather as guidelines. After all, it is the role of the architect to translate the wishes of the client into a design. Through individualisation, the general community feeling is weakened, people often feel more connected to a 'peer-group' where there is no physical connection (Nayar, 2009). The architect should help the client to understand what is needed over time (Hershberger & Smith, 2017) and provide a space where the client can determine his or her life within the physical community (Kuhn & Harlander, 2012)

THE FUTURE OF THE BIG HOUSE
CONCLUSION

The composition of households is ever changing, based on political and social context and changes within over time. Furthermore time itself causes changes within households with children moving out and the residents of the house simply ageing. This means household demographics will never remain the same, even when only considering a single place.

The ideal picture in the western world is the single family house a couple got to buy after getting married, quickly followed by having children. This kind of single-family house has long been the image of the most ideal house type. It is a way to reach for a degree of comfort and safety that is more than a different type of house could offer. But it was only achievable for those who could afford it, which made it a place of luxury, a prestige object to separate the owner of the masses. Today luxury is something we can all aim for and the classical villa is not the only option for this anymore. Still money will continue to be a dividing factor, especially now the inequality grows around the world, and housing will stay a means to showcase wealth. There has been a decline in the amount of traditional nuclear families and an increase in single person households. The demographics are further shifted as a result of the currently ageing society. For architecture these changing demographics allow for a new view on housing. The traditional family homes do not meet the requirements of many single person households and elderly have different requirements as well. Reacting to these changes is key in sustaining the housing market and architectural design can play a key role in this, providing the market with a new influx of housing designed to its future resident's needs. What is certain is that the architect designed private house is changing and will continue to change in the future.

Achieving luxury in the form of a private house does not necessarily mean a large villa with private garden anymore, although this type will live on. Luxury today means much more the expression of individual ambitions, uniqueness and craft, and because of that, new types of the private house enter the field. The size of the house too becomes less important. As society becomes more pluriform, so becomes the expression of the architect designed private house. Informality tends to become a more influential notion when it comes to the division of spaces. Nowadays, not every facility within the house inherently needs to be physically separated by means of interior walls. On the contrary, functions seem to merge into single spaces. This trend already emerged in the early 20th century. This era's architects contemplated functions co-existing harmoniously in one single space, rather than subdividing every single activity into small units.

This development, however, questions the subject of privacy within the private house regarding its household. The extent to which functions join together, influences the balance between public and private. The increasing informality seems to evoke a certain paradox. Private houses become more and more public as layout gets more informal, while at the same time individual lifestyles seem to increasingly play an important role. Diverse schedules and concerns of the individuals within each household require areas for retreating, away from the blend. This is seen being translated to interior walls focusing on the separation of individuals, rather than the functions. The presence of individual rooms to preserve a necessary amount of privacy, will become increasingly important in future housing design.

In recent years and especially now in this strange time with the Corona virus, a shift is taking place. People are increasingly working hard, especially now that measures have been taken that everyone should work from home as much as possible. Many clients choose to create a place in the residential environment (public) where work (private) can also take place. Where there is no hard separation to be found at Ennis and Tugendhat , this can be found in for example the Möbius house by Ben van Berkel and Casa Poli by Pezo von Ellrichshausen.

Because there will probably be more and more work at home, design will also have to be taken into account. For example, opportunities will have to be created for spaces where people can work in a quiet way, (private) but also spaces where family life has an important role.

In the 17th century the private house of the middle class became for the very first time truly private. For the first time, the middle class was getting wealthy enough to separate their business from their home. Resulting in the banishment of the public from the private house. Now, with the rapid technological advancements, this development is starting to reverse. Ever more people are starting to see opportunities to run a business from home. At the same time, various advancements are providing possibilities for workers to do the work that they would usually do from their office from their homes. Due to the pandemic in 2020 these developments will gain only more momentum.

On the same time, the merging of working and living are closely related to the erosion of functions. The increasing informality has contributed to this development greatly, and will likely continue to contribute for the foreseeable future. It is however important to keep in mind that there are various indications that show the importance of a retreating space for individuals within a house. To be able to work from home, a space that is separate from other members within the household seems paramount. For single family households, on the other hand, the physical separation between working and living within the same house is of less importance, as can be seen by the popularity of loft living, where the entire space is associated to a dynamic working and living merger.

Something that has always distinguished the villa from other types of housing is its association with exclusivity. Particularly to exclude oneself from everyday life in the city. This usually meant that one would retreat into a calm area just outside the city, or on a rural estate. However, in modern society, the city is no longer an insanitary place to flee from. Instead, the social aspect found in urban life is often an attracting factor, especially for younger generations. The ability to connect and network makes the city a viable option for living. The rural retreat is far from obsolete in today society, but the active city is currently booming again.

Due to societal and technological advancements, we are no longer bound to a specific place. We can travel around the world in a day, we live hours away from our workplace and we can connect with everyone around the globe within seconds. We therefore have a relative free choice in a location of our residence. This also means that locations for architecturally designed private houses become less location specific. Preference of lifestyle or certain sought-after assets within the landscape prevail practical considerations with regards to location. Also, major metropolitan cities around the world start become more similar due to globalization. It no longer matters whether one is based in London or Amsterdam, the same urban features are available in both cities.

THE FUTURE OF THE BIG HOUSE

DISCUSSION

Photo © Hans Werlemann, courtesy OMA
Maison a Bordeaux, OMA. Built in 1998. Interior.

Firstly, it is important to understand the context in which this research was conducted. This research is the product of the BIG House 2.0 Graduation Studio that started in February of 2020 at the Eindhoven University of Technology. The studio was created as an extension to the BIG House master project that started at that same time. It is important to note that the entirety of the research, as it exists in its current shape, was conducted during the lock-down that was initiated as a result of the 2020 pandemic. As the crisis is far from over when this research is being rounded up, the predictions that were related to it will have to be revisited over time.

Another important consideration when reviewing this research is the limited scope of case studies that is used to support the text. The case studies are used for illustrative purposes to showcase some of the trends that are being expounded within the research. No reasonably accurate or concrete conclusions can be drawn from looking at just the scope of case studies without the text as a body of reference.

Thirdly, it is important to note how this research places itself in a Western context, where both the texts as well as the case studies that are drawn upon are mostly European. Even the Americas play a small role within the scope of this research.

Another important consideration when reviewing this research should be that the built environment evolves rather slowly. Trends that we observe might have been ongoing for several decades, or even since the introduction of Modernism. This means that it is somewhat safe to say that most trends will go on for a while. On the other hand, times are changing fast, with the quick evolution of technology, and the ongoing pandemic. Making it hard to predict which trends will continue, and which ones might stop entirely. These developments also make it hard to predict what new trends might emerge during these times, and what newly emerged trends are in fact going to survive.

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PART II

DIGITAL MANUFACTURING

INTRODUCTION

This part of the research was is a collaborative effort from Roy van Asten, Eva Boon, Lars Breukelaar, Esmee Dieteren, Roy van der Heijden, Michiel Peeters, Annine Rozema, Chi Wong, Jorn van Wegen and Jorik van der Zeijl as an exploratory research into the context of digital fabrication as a part of the Big House Graduation Studio, under the supervision of Zeeshan Ahmed and Christina Nan.

This research will first explore the state of the art of digital fabrication of surface level. Then the research will be further specified into the digital manufacturing within the construction industry. Here the focus will be on additive manufacturing, specifying the main used techniques in extrusion based printing.

The second half of this part of the research will expand on a relatively new digital fabrication technique that shows great potential for the construction industry. Various new experiments and new possible developments for this technique have been conducted and designed to help further develop this technique for real-world application in the construction industry.

DIGITAL MANUFACTURING
PROBLEM STATEMENT

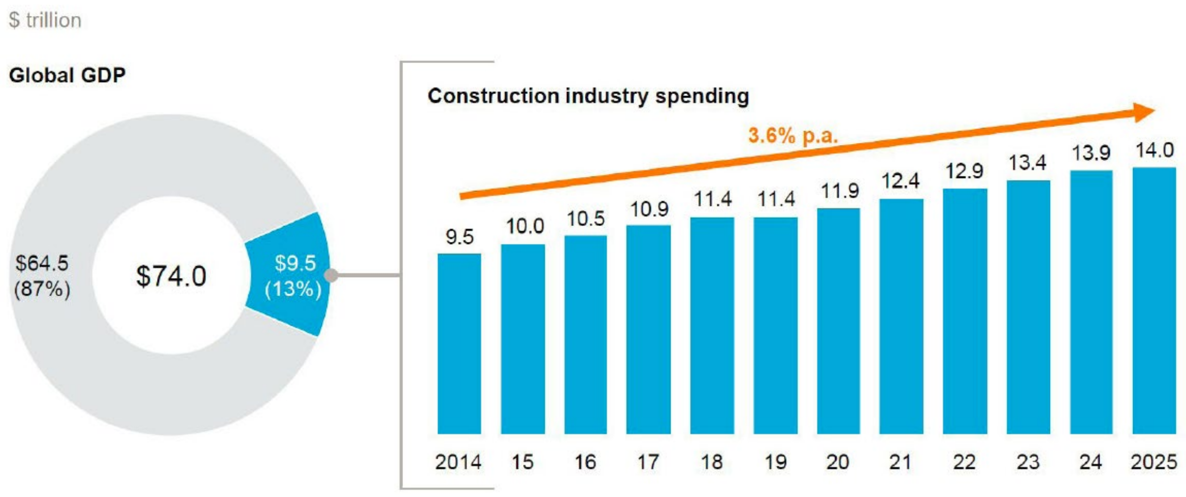


Fig 1.1: Construction Related Spending [3]

CONTEXT

The Architecture, Engineering and Construction (AEC) Industry is trying to pursue digitisation and automation for a higher productivity. Advancements are being made regarding automation and robotics, but the industry is a long way from fulfilling its potential.

The problem is that the current state of the AEC industry shows a minimal growth in this digitisa¬tion and automation. Labour productivity is extremely low compared to other industries, and the supply chain of the AEC is too complex. This brings inefficiency between different parties in the construction process.

Automation in constructions can bring about solutions in digitisation for the construction process by using additive and subtractive manufacturing. These will improve the quality and productivity, but also safety and other factors, by adopting digital technologies in the industrial production. This will become important for speeding up the construction process with on-site automation, such as 3D printing with robots.

The global population is estimated to increase with 81 million people per year [1]. Most of these people will live in urban areas, as currently, the world's urban area is increasing by 200,000 people per day. All of whom need comfortable housing, as well as transportation and utility infrastructure [2]. The entire population relies on the quality of the AEC industry to live com¬fortable lives [2]. This growing rate at which buildings are being constructed also has an increasing impact on the environment. With three billion tonnes of raw materials used to manufacture buildings worldwide, the AEC industry is the single larg¬est consumer of resources and raw materials [2]. All these resources leave behind immense waste; about 40% of all solid waste derives from the construction and demolition of buildings [2]. Apart from material impact, the AEC industry also eagerly consumes other resources like oil and fuel for machinery, which accounts for approximately 20% of the total materials [3]. Consequently, the industry is responsible for 30% of the world greenhouse gas emissions [4].

The big impact of the AEC Industry on our lives also has a positive note. The AEC industry fuels global economic activity in a wide range of sec¬tors [3], providing more than 100 million jobs worldwide [2]. Around $10 trillion a year is spent on the industry, which translates to around 13% of the global GDP, see figure 1.1 [2], [3], [5]. The spending is increasing with 3.6% since the end of the financial crisis and is expected to con¬tinue to at least 2025 [3].

DIGITAL MANUFACTURING
PROBLEM STATEMENT

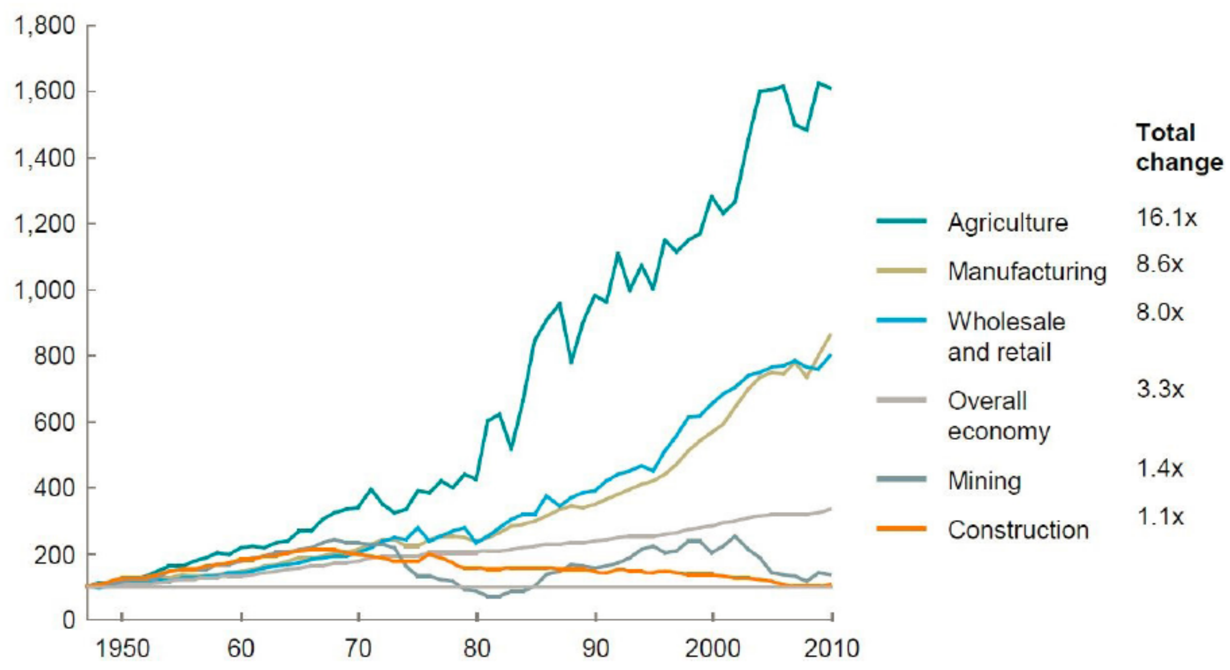


Fig 1.2: Labour Productivity: Value Added per Hour Worked [3]

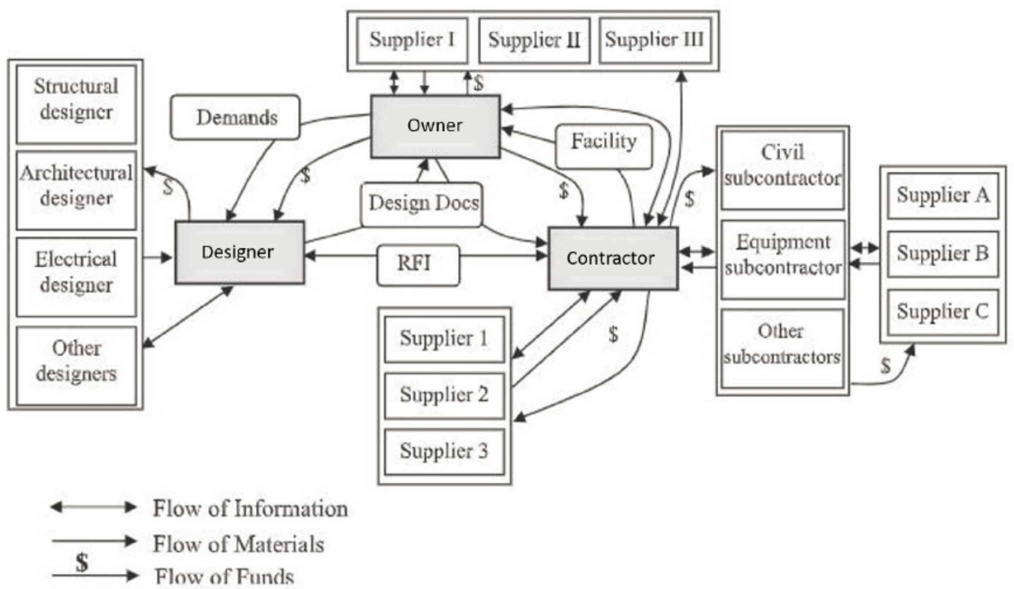


Fig 1.3: Complex Supply Chain in AEC Industry [9]

CURRENT STATE OF THE AEC INDUSTRY

In this rapidly advancing world, the AEC Industry faces some urgent problems. The biggest prob¬lem regards its labour productivity. The labour productivity of the construction industry over the past 70 years has only increased with factor 1.1x, see figure 1.2, whereas other comparable industries, such as manufacturing (8.6x) and agriculture (16.1x) have grown significantly.

The main reason for this low productivity is the manual labour required for construction pro¬jects. Whereas other sectors have mechanized, digitized or robotized, the construction industry is still considered low-tech [4]. Despite some highly technical and complex projects being undertaken, construction has largely continued to rely on traditional methods characterized by poor quality and performance [3], [4]. Little has changed over the past 800 years; pulleys have been substituted by cranes, but they work with the same principles: manual control, human operator visual feedback, big positioning error, etc [6]. Whereas other sectors have boosted productivity by innovations, the productivity within the construction industry has actually declined in some markets since the 1990s [7].

The poor labour productivity of the construction industry is pervasive. It is a long-term issue that affects virtually every economy, and which has not been tackled for decades [3]. It is esti¬mated that a 1% increase in productivity could save around $100 billion in construction costs [2]. The cost to the industry is substantial, but therefore so is the opportunity [3].

Another problem is the complexity of the supply chain in the current AEC Industry. Building developments involve complex decision making [8], which is being fragmented into smaller firms. In total, around 2.7 million enterprises are currently involved in the industry [6], all of which have their expertise. This results in a highly complex system of relations. Xue et al. visualise this complex supply chain, as can be seen in figure 1.3 [9].

DIGITAL MANUFACTURING
PROBLEM STATEMENT

Fig 1.4: Industry Digitization Index; 2015 or latest available data [10]

DIGITISATION & AUTOMATION

One of the solutions to countering these prob¬lems is to digitize the construction industry. Other industrial sectors, such as automotive, aeronautics and aerospace underwent radical process changes by adopting digital technolo¬gies to improve quality and productivity, these transformations are generally described as industry 4.0 [4], [6]. In contrast, the construc¬tion industry is one of the least digitized sec¬tors, see figure 1.4, which indicates that a lot of improvement can be made in this field.

There have been advancements in digitization in the construction industry, but these have mainly been at the planning phase (planning, suppliers' relationships, etc.). Those advancements have not been translated to the production phase of the process (building erection, masonry, on-site automation) [6], [11]. The core of the problem will not be solved by these partial advancements; a digital solution should cover all phases of the construction process.

Digitization in the production phase can be achieved by Robotics and Automation in Construction (RAC). This brings some highly desirable advantages to the industry. First and foremost, RAC has the ability to improve the construction efficiency, and with that, increase labour productivity [3], [5], [6], [12]. This improvement will particularly be effective when elements are manufactured on-site. This is mainly due to the precision that the robotics can deliver [5], [6], [13]. Another factor is the qual¬ity of the product [5], [6], [12], [13]. Similarly to prefabricated elements that are more and more common on construction sites today, elements produced with RAC will be constructed under a controlled environment. This will guarantee products with similar high quality throughout. RAC will also greatly influence the impact of the AEC industry on the environment [14], [15]. The precision of the robotics provides a tool for the precise placement of material, therefore reducing the overall material usage compared to tradition methods. Also the highly labour intensive and wasteful production of formwork is no longer needed [16], [17], which has a pos¬itive impact on the environment. Apart from the construction process, RAC is capable of simplifying the whole process, from design to manufacturing [3], [13]–[15]. This integration of information can simplify the complex supply chain of figure 1.3. Everything happens in one digital flow of information; a phenomenon from which the industry can learn from other sectors such as the automotive or aerospace industries.

However, overall it should be noticed that RAC will not simply solve all these problems. It is a tool which can improve part of the problem. One of the more promising tools is additive manufacturing, which will be covered in the next chapter.

DIGITAL MANUFACTURING

ADDITIVE MANUFACTURING

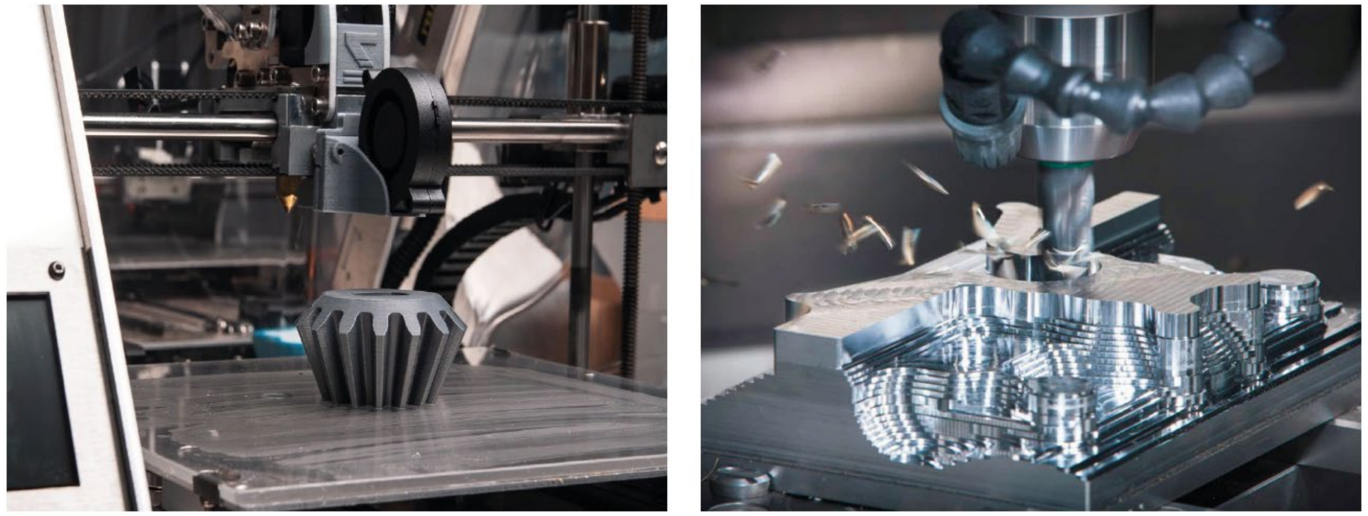


Fig 2.1: AM process (left) and SM process (right)

AM VERSUS SM

Additive Manufacturing (AM) is a technology that has transformed our perception on how products are designed and produced, AM is defined as; ‘’a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing (SM) and form¬ative manufacturing methodologies” [18]. The way AM operates is by creating a computer-aided design (CAD) model which will be digitally sliced in individual layers, the design will then be build up layer by layer [19]. The term AM was used to be called rapid prototyping (RP), which describes this ‘rapid’ process for creating a prototype etc. the most popular term for AM is called 3D Printing [20]. In contrast to AM, there is another type of manufacturing, namely subtractive manufacturing (SM). SM is removing material instead of adding material, like AM does, which is more a conven¬tional technique of manufacturing, figure 2.1 shows the processes of both AM and SM.

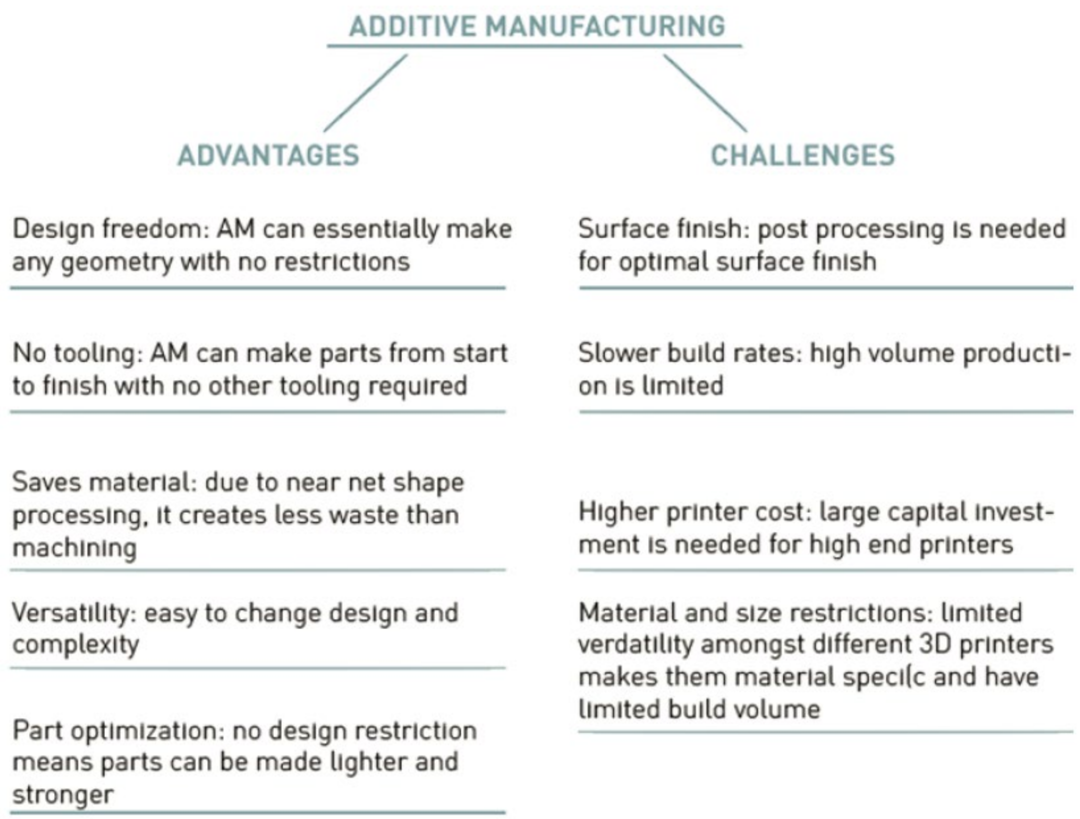


Fig 2.2: Advantages and challenges of AM [21]

ADVANTAGES OF AM OVER SM

Compared to traditional manufacturing meth¬ods and other methods, like SM, AM has sev¬eral advantages as "AM has now reached a point where it is ready to be implemented for industrial use'' [21]. Figure 2.2 summarises the advantages of AM as well as the challenges of this technique. The most characteristic of AM processes is that production is done by just one machine, this is why complex geometries are even more possible compared to the use of conventional methods, thus providing a lot of design freedom [20]. Unlike AM, SM is not as detailed when it comes to design freedom. This is caused by the fact that SM requires a cutting tool, producing parts is more difficult cutting into very thin material, for example, than it is to simply produce a layered part according to a CAD model [19].

Another advantage being that AM can make parts from start to finish, ''the only tooling involved is a single AM machine, so a constant tooling cost is eliminated" [20]. Partly because AM can produce a part from start to finish, this also ensures that there is little material loss, this can lower the reduction of materials by 75% and lower the costs and production time by 50% [21]. This is in contrast to SM products, where a lot of material loss occurs because you remove material. However, the advantage of SM com¬pared to AM according materials is that AM is developing its material use thus more high-end machines are required, while "SM can make products out of almost any material. It is a proven and rugged technology, which has been using for ages" [19]. Another advantage for AM to easy change the design and complexity of it,is the versatility. The Versatility of AM makes it easy to alter design decisions even during the production process. AM can offer this versatility due to digitization using CAD. Also, the advan¬tage is that unique designs are more equal to standardized products now because the AM process can replace the specific crafts and/or equipment's to only using digital inputs. ''Thus the producing costs of customized product will be more or less the same with standardized ones, and individualized buildings will be pro¬moted'' [13].

The 'final' benefit according to figure 2.2 is the part optimization, it states that there is no design restriction for optimize a design. This is similar as Topology optimization, which is according to [22] ''a computational material distribution method for synthesizing structures without any preconceived shape.''

Not only are there advantages to using AM, but there are also some challenges worth mention¬ing. For example, the surface of AM products need post processing because of the layered effect this technique has. For SM it is possible to vary in surface finishes by choosing the optimal set of machining parameters, but this process of SM surface finishing costs a lot of energy [19]. The build rate for producing large quantities of AM products is limited, the process is expensive because of the high investment which is needed for example high end printers, and another challenge is the material and size restrictions which are limited because of the different 3D printers.

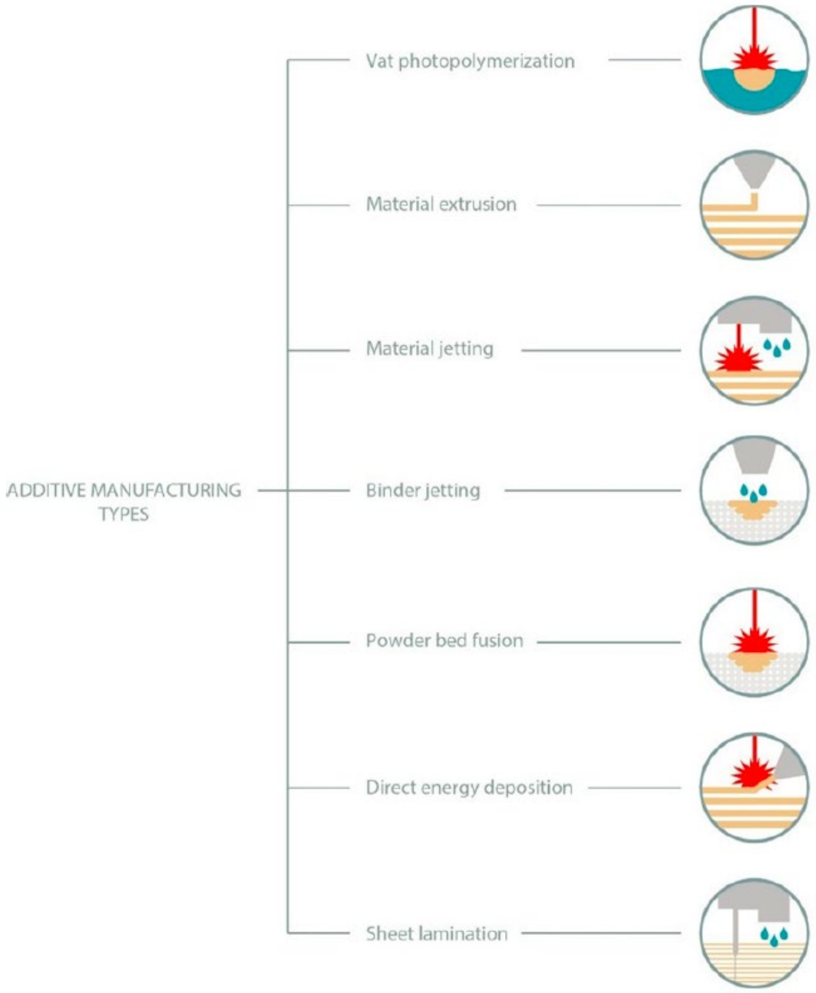


Fig 2.3: Different types of AM Technologies [21]

AM TECHNOLOGIES

AM has many different technologies. The differ¬ent technologies are visible in figure 2.3 and will shortly be elaborated. All main technologies also consist of different types of additive man¬ufacturing. These are not mentioned here. The pictures next to the technologies show the main concept of the additive manufacturing technol¬ogies.

VAT PHOTOPOLYMERIZATION

Vat photopolymerization is a process in which UV light is shined onto a photopolymer resin. As a result, the resin cures and a hard layer of resin is formed. This process is repeated sev¬eral times according to the geometry as drawn in the CAD model. After a layer is hardened the next layer can be produced until the model is completely realized [19].

MATERIAL EXTRUSION

Material extrusion, also known as extru¬sion-based AM, is a very well-known way of additive manufacturing because of its cheaper set-up and hardware. In this process, a material raw material is extruded onto a plate by means of a nozzle. The model is formed according to the CAD model and built up layer by layer [19].

MATERIAL JETTING

Material jetting can be compared to the tech¬nique used with 2D inkjet printers. A photosen¬sitive polymer is applied by means of drops to a plate after which the polymer is cured by means of UV light. After this, the plate is taken down and this process is repeated. This creates an object layer by layer [19]

BINDER JETTING

The binder jetting process is characterised by the process of spraying a liquid binder onto a thin layer of powder through a print head. After the subsurface has been lowered and the next layer of powder has been sprayed, the overall model is gradually realised. When the work is finished it remains in the powder to harden and gain strength. After curing, the excess powder is removed by means of a jet of air [19].

POWDER BED FUSION

Powder bed fusion involves the process of sin¬tering or melting a powdered material by means of a thermal energy source such as a laser or electron beam. The sintering takes place layer by layer in order to arrive at the final object. The spreading of the different layers of powder is done by a mechanism of a roller or a blade [19].

DIRECT ENERGY DEPOSITION

Direct energy deposition refers to a method in which the building material, a powder or wire form is heated, melted and bonded. The energy is supplied by a laser or electron beam focused on the building material [19].

SHEET LAMINATION

Sheet lamination is the layer by layer lamination of paper material that is cut by a CO2-laster. Each layer represents a cross-section of the CAD model of the part [20].

3D PRINTING IN CONSTRUCTION

Fig 3.0: Project Milestone [63]

INTRODUCTION

Within the context of the AEC industry, the process of additive manufacturing is dominated by printing techniques that use concrete-like materials, and is therefore often referred to as 3DCP (3D Concrete Printing). A reason for the almost exclusive use of cementitious materials can be found in the fact that very little research has been done into the load-bearing capabilities of other materials in a context of additive construction [36]. From this point on, all AM techniques that are being discussed are related to the AEC industry and involve a nozzle of types, and will therefore be referred to as 3D printing techniques, or 3D printing techniques of cementitious materials, or 3DCP to narrow down the focus of the research.

In the AEC industry, not all 3D printing techniques are used to the same extent. The extrusion based process seems to be the most valuable printing process within the context of AEC. Followed by the powder bed fusion technique. On the other hand, a relatively new technique called spray printing is showing various interesting developments in the field of additive construction. These three 3D printing techniques will be briefly introduced in the context of AEC, after which we will explore the extrusion based printing process of cementitious materials in more detail to create a comprehensive overview of the state of the art of 3D printing within the field of construction.

Fig 3.1: Double Curved 3D Concrete Spray Printed Wall [38]

SPRAY BASED PRINTING

The spray printing of concrete, or 'shotcrete printing' has only recently been researched in the context of 3D printing techniques. The tech¬nique of shotcrete itself has been around for more than a 100 years already. Applications for it can be found in the mining and construction industry [37]. However, relatively recent, the universities of Braunschweig, Clausthal and Hannover started looking at the possibilities of shotcrete as a 3D printing technique in the construction industry.

The process of spray printing concrete brings with it some advantages over other 3D concrete printing techniques. The first is the possibility to spray print on vertical surfaces. A useful application of that technique can be found in the double curved reinforced concrete wall that the university of Braunschweig developed in 2020. The wall is initially built up by depos¬iting layers of concrete on top of each other, similar to how one would print a concrete wall using the extrusion based process. In between some of the layers, horizontal reinforcement is applied. Then, vertical reinforcement is placed against the wall, which is then vertically being spray printed over, to create a strong reinforced double curved concrete wall (figure 3.1). Other advantages include the excellent bonding of various layers, and the possibility to introduce additional accelerators to adjust the solidifica¬tion times [37].

The spray printing of concrete is however a rather difficult process, with many parame¬ters that influence all aspects of the outcome. Such aspects include the layer thickness, the early strength and the concrete quality. The many parameters that need to be taken into account are the spraying distance, the spraying angle, the concrete volume flow rate, the deliv¬ery pressure, the air volume flow rate, the air pressure, the concrete accelerator dosage and parameters related to the path planning such as the nozzle distance, velocities, layer spacing, application angle or times between layer appli¬cations [37].

Fig 3.2: Radiolaria Pavilion printed by Dini's D-Shape Printer [42]

Fig 3.3: Dini's D-Shape Printer [43]

POWDER BASED PRINTING

Besides the extrusion based processes , the powder bed fusion based processes is currently the most valuable contributor to AEC in the field of 3D printing techniques. The process is based on the transformation of a material from a powder state to a solid state. This transfor¬ma-tion might be achieved by sintering, melting, applying an energy source, or by means of a chemical reaction [36]. When the process is complete, the residual powder may be removed and reused in a next printing session.

The powder bed process in the AEC context makes use of a concrete-like powder, rather than the metals which are usually used in this process in other fields [36]. In AEC a powdered concrete mix is often used which is cured by means of hydrating the mix using an ink jet spray [39].

One of the things that makes the powder bed based pro-cess extremely beneficial to the con¬struction industry, is the fact that there imme¬diately is a supporting struc-ture, which is the powder that in not used for the object that is printed at the time. This means that it is much easier to create objects with overhangs or arches [40].

On the other hand, however, the powder bed is much more vulnerable to exterior influences such as the weather [40]. This makes it difficult to apply this process to in situ constructions. Instead, most powder bed based objects are thus printed off-site. Making that an impor-tant constraining consideration during the design phase.

The most notable approach of powder based printing is the D-Shape, which was invented by Enrico Dini [41]. The D-Shape approach produced what is generally also con-sidered to be the first large-scale additive manufactured structure, which is the Radiolaria Pavilion [36], which can be seen in figure 3.2. It was built in 2006, using the earliest version of Dini's D-Shape printer.

DIGITAL MANUFACTURING

EXTRUSION BASED PRINTING

Fig 4.0: AI SpaceFactory's building 3D printer

INTRODUCTION

By now we have covered powder based printing and spray based printing, but by far the most used 3D printing technique in construction at this point in time is extrusion based printing [36]. The process involves the deposi¬tion of a material in a liquid state by means of a printing nozzle [36]. Once the material is depos¬ited, the curing of said material will result in a solidified whole. Examples of such processes are Fused Deposition Modelling, PolyJet and Inkjet.

Within the context of AEC, the extrusion based printing techniques can be roughly divided into two categories. The first category is the extrusion based printing of thermoplastics. There are no structural applications for this process in the construction industry, as it is mainly used for prototyping. We shall therefore not further discuss the topic of extrusion based printing of thermoplastics. The other category of extrusion based printing, is that of cementitious materi¬als. This is by far the largest category that has any bearing in the AEC context.

The extrusion based printing process of cementitious materials is based on the computer-controlled continuous extrusion of a cementitious material by means of a nozzle, while depositing various layer on top of each other to create an object in three dimensions [36]. Extrusion based printing offers a cheap and fast alternative to traditional construction. It has the potential to fully transform the AEC industry [44]. In order to understand the current state of the art of this 3D printing technique, this chapter will firstly cover the system engineering aspect of it. Then the material properties will be discussed. Thirdly, the importance of various design methodologies will be covered. And lastly, various applications of extrusion based printing will be elaborated.

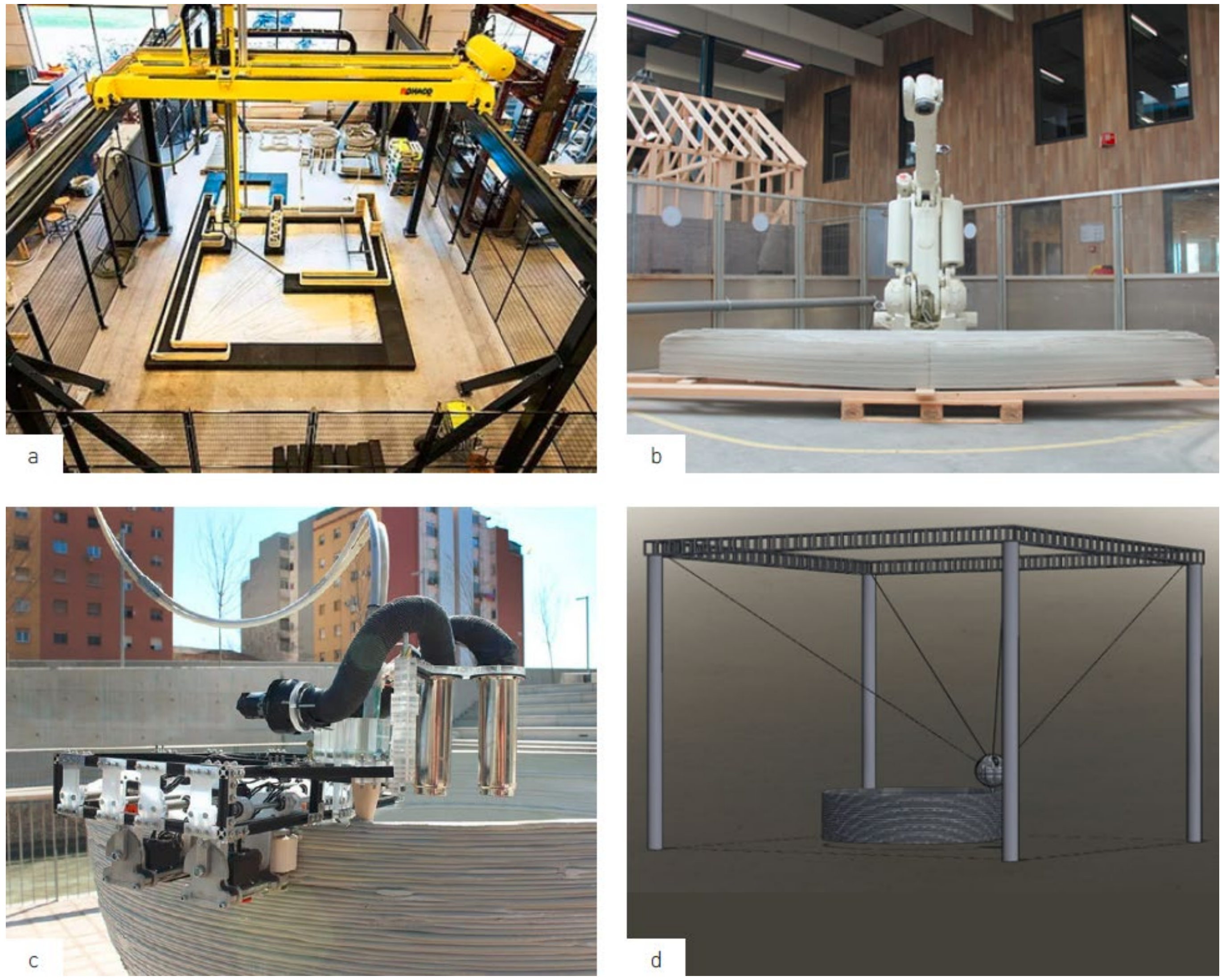


Fig 4.1: Types of extrusion based robots;
a: Gantry system at the TU/e [45], b: Industrial robotic arm at Vertico [46],
c: Robotic swarm technology by MINIBUILDERS [47], d: Cable suspended "spider bot" by MIT [48]

DELIVERY SYSTEM ENGINEERING

The relevant hardware that needs to be discussed when talking about 3D concrete printing in the AEC context can be subdivided in the type of robot that is used, the printer head, and the delivery system. The extrusion based printing of cementitious materials is currently being executed by four different types of robots. These are the gantry system, the industrial robotic arm, swarm technology, and by means of cable suspended robots.

GANTRY SYSTEM

An example of the gantry system can be found at the university of Eindhoven (figure 4.1a). A gantry system operates on a structure, that allows the printhead to move in the X,Y and Z direction. It offers the advantages of being able to print relatively large structures, up to the size of a whole building. A gantry system generally has three, or sometimes four degrees of free¬dom. The first gantry system being developed for concrete extrusion was used for the Contour Crafting process, as invented by Khoshnevis from the university of South Carolina [36].

INDUSTRIAL ROBOTIC ARM

Another type of robot that is widely used in 3D concrete printing, is the industrial robotic arm (figure 4.1b). The robotic arm mostly offers six degrees of freedom. It is more precise and accurate than the gantry system and therefore, the robotic arm is thus often used for smaller objects with more detail present. The downside of such a robot is the limited printing area, due to the restrictions in the size of the arm. Another challenge that is posed by the robotic arm, is the fact that a deeper knowledge of the programming of such a robot is required in order to correctly operate it.

ROBOTIC SWARM TECHNOLOGY

Robotic swarm technology might pose a future solution to some of the challenges that the industrial robotic arm faces. The idea of swarm robotics rejects the use of a single robotic entity, but instead, makes use of various smaller mobile robots (figure 4.1c). The swarm tech¬nology is especially interesting and practical for 3D printing in extra-terrestrial environments, where transportation is an important limiting factor on the size and weight of the robots [36]. The swarm robots can navigate their own way through a construction site, which again is very beneficial in extra-terrestrial environments, but also on harsh earthly environments [36]. One of the key aspects to get swarm technology to truly work, is to provide the robots with the ability to climb the structures they build. That way, they are not dependent on a large gantry system, or long robotic arms. One institution that made this a reality is the Institute of Advanced Architec-ture of Catalonia with their Minibuilders project.

CABLE SUSPENDED ROBOTS

The cable suspended platform, as is shown in figure 4.1d is rather similar to the gantry solu¬tion. However, it has various advantages over the gantry solution. The cable suspended printer has a structure that uses less material, which makes it easier to move around and thus making it easier to cast in place. Due to the fact that it consists of less parts, it is also much quicker in assembly and disassembly [36]. Another advan¬tage that the cable suspended platform offers is the possibility of having a print head with six degrees of freedom, rather than the three or four that the gantry solution offers. The cable suspended platform is still in early development stages, but various institutions are investigating its possibilities and its potential at this point.

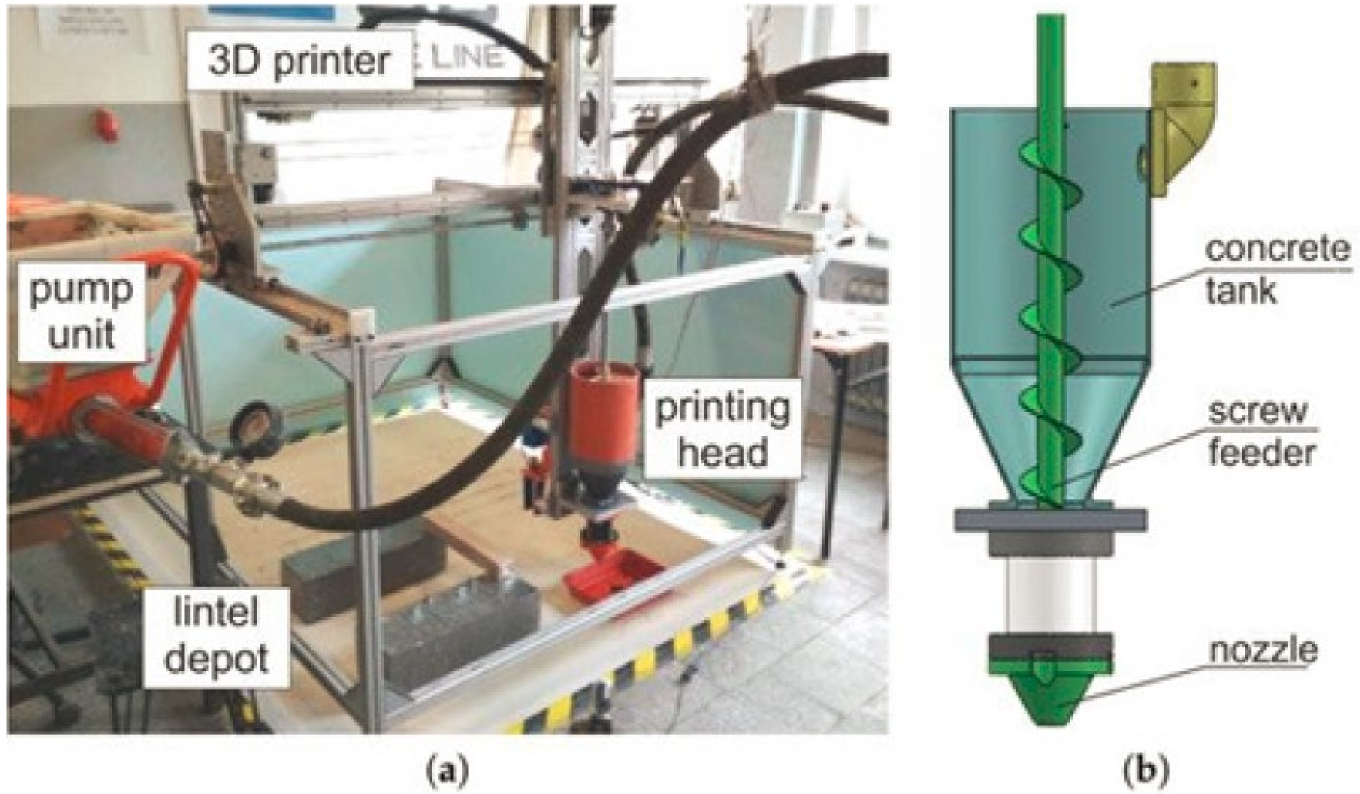


Fig 4.2: Printing Head and Delivery System [50]

NOZZLE SYSTEM ENGINEERING

PRINT HEAD AND DELIVERY SYSTEM
Besides the type of robot, the print head itself of said robot has a huge impact on the 3D printing process. The print head usually consists of an extruder, a nozzle, possible side trowels, and a case with an Archimedean screw that forces the concrete out of the nozzle.

The nozzle may come in various shapes, which will help achieve the desired shape, size and buildability of any particular concrete layer [44]. Overall, it seems that the circular shape of the nozzle offers more freedom, as the angle does not need to be changed to correct for changing angles in the path [49]. The size of the nozzle may differ, depending on the desired width of the beads. The orientation of the nozzle must be applied tangent to the tool path [44].

The speed of the print head needs to be care¬fully calibrated, otherwise too much or too little material will be deposited, which might result in an increased or decreased bead dimension, which in turn will impact the finished object [49].

Some printer heads have trowels and the end of the nozzle, to help smoothen the surface of the concrete once it has been deposited. This also ensures a more consistent bead width.

In most cases the supply of the materials happens through a pump, which acts as the delivery system. Before the pump a mixing unit is located within this delivery system. The mixing unit provides the specified concrete mix, which is usually a high viscosity past like mix, to ensure the shape is retained when printing [49]. This also means that the pump needs to be rel¬atively strong in terms of pressure, to transport said mix to the nozzle. Often, a variety of aggre¬gates will be present within this mix, providing an extra difficulty to the pump. Alternatively, the concrete mix can be made with a higher vis-cos¬ity, as long as additives in the nozzle are injected into the mix to make it quicker to cure [49].

The other half of system engineering consists of software engineering. An important consid¬eration here is the toolpath. The toolpath is the path that the printer head needs to follow when extruding the concrete. It is important to realise that each 3D printer comes with its own software. On top of that, all software that was used during the design process, has to be able to work together with the software of the printer itself.

DIGITAL MANUFACTURING
EXTRUSION BASED PRINTING

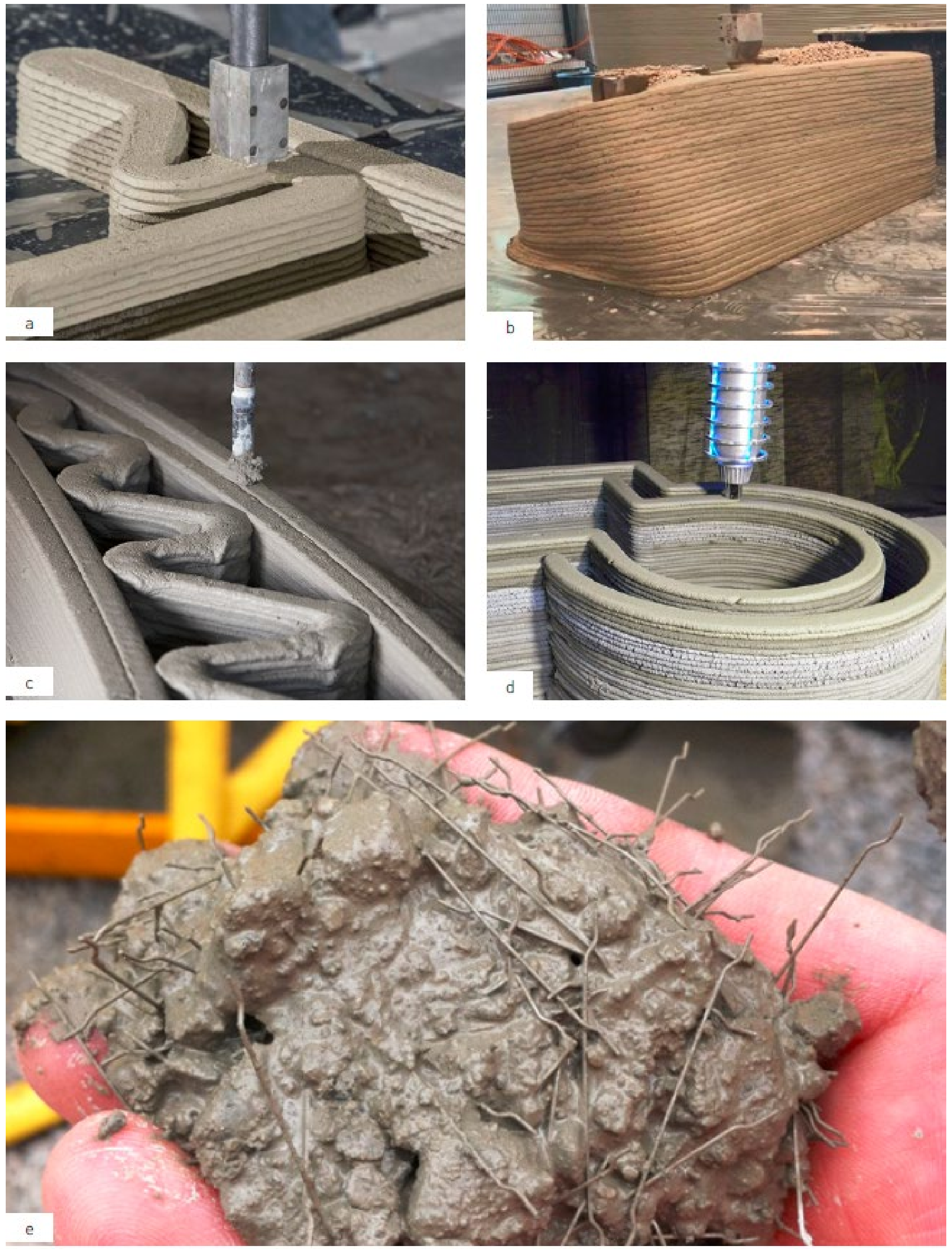


Fig 4.3: a: Consistent extrusion, b: Buckling due to inappropriate buildability, c: Support structure to improve buildability, d: Bonding between layers, e: Addition of fibers

MATERIAL ENGINEERING

Concrete is to the present day the most used building material in the world. The raw mate¬rials neccesary for producing concrete are cheap and commonly available in most areas. Its popularity is mainly due to its compressive strength, fire resistance and the fact that it can be applied in any shape because of its fluid state before setting. The actual composition in practice in general at least consists of a mixture of a cementitious material and water, together with a filler of sand, gravel or another granu¬late material. These are often complemented by additives like aggregates [44]. Regarding the 3DCP extrusion based process, the traditional concrete can't be applied instantly. The com¬position of the concrete is of high importance as there is an absence of formwork. In order to accomplish a consistent extrusion of material, research of the rheological properties of con¬crete in its fresh state is required. The influen¬tial factors of the material in its fresh state is defined by the characteristics of pumpability, extrudability, buildability, interlayer adhesion and open time. The latter concerns the time the fresh concrete needs to set. It defines the time between completing the mixing and the initial setting time of the material [49].

4.2.1 Pumpability and extrudability

Pumpability concerns the material's mobility and stability. In order to pump the material, a relatively soft mixture is required. When the concrete reaches the nozzle, a somehow more stiff material is desired so it does not slump while being extruded. The composition of the extruded concrete should be well-considered as it largely influences the pumpability [49].

As the material is being pumped over a dis¬tance, depending on the printer size and the desired working volume, the fresh concrete is less viscous when reaching the nozzle com¬pared to traditional extrusions. The extrudabil¬ity covers a proper and consistent extrusion of the material, where it should retain shape when extruded through the nozzle (figure 4.3a). Pres¬sure differences may arise as the nozzle and pipe often differ in cross-sectional dimension. Material proportions should be carefully chosen and controlled, as a failure might lead to seg¬regation of the mixture and possible material blocking in the pipe or nozzle [49].

4.2.2 Buildability and interlayer adhesion

Once extruded, the material's buildability refers to the printed layers being able to hold the sube¬quent layers on top. It is of high importance that the material is self-supportive and it should be resistent to collapsing and deforming. Imper¬fection of layers could lead to instability as suc¬cessive layers are added (figure 4.3b). A way to improve the buildability is to create a supporting filament [49]. These are printed adjacent to the actual structure to ensure a stable printing environment (figure 4.3c).

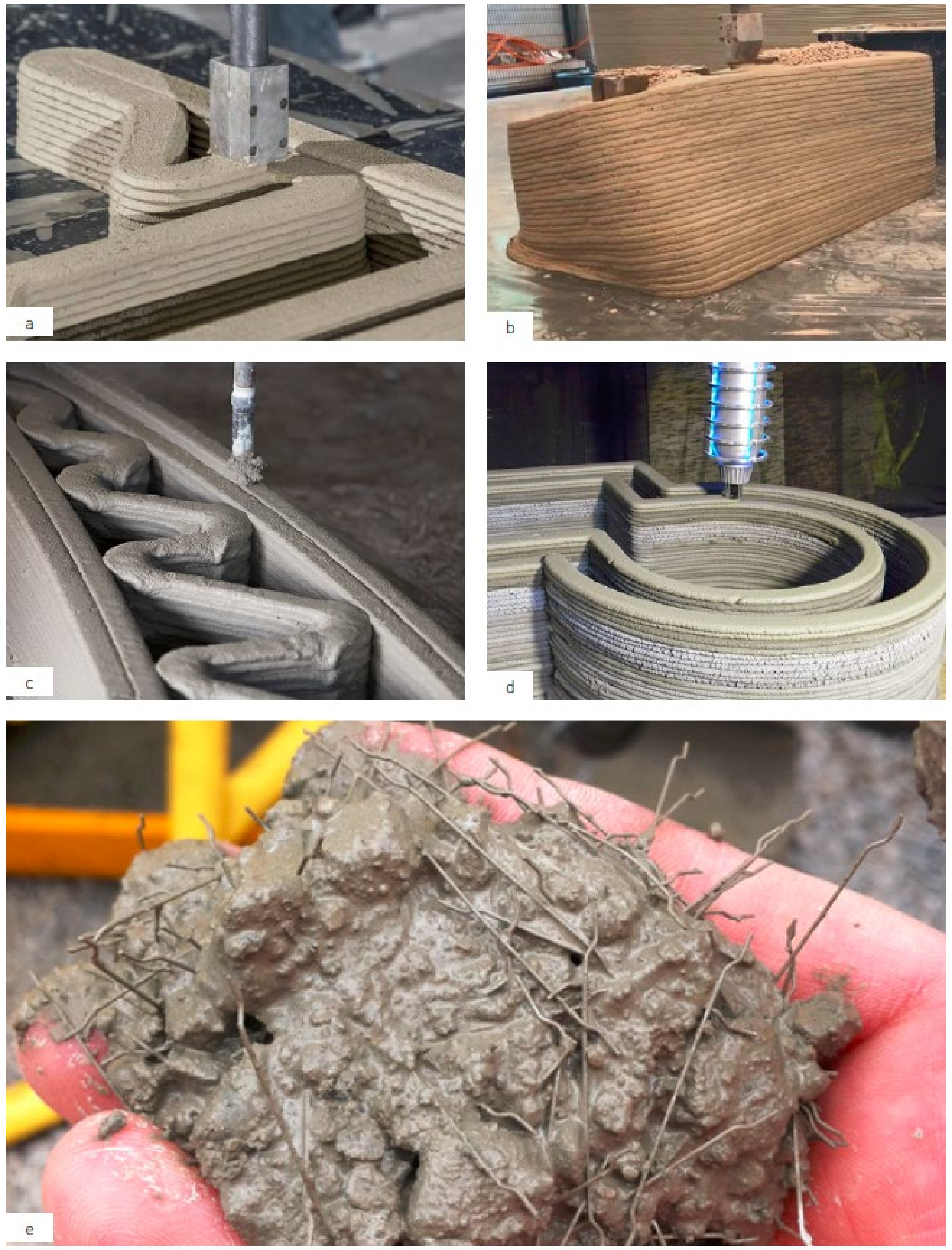


Fig 4.3: a: Consistent extrusion, b: Buckling due to inappropriate buildability, c: Support structure to improve buildability, d: Bonding between layers, e: Addition of fibers

MATERIAL ENGINEERING

Additionally, when extruded, the material should set as fast as possible to remain shape. However, it should not dry too fast as it should still bond with the subsequent layer (figure 4.3d). This covers the parameter of inter-layer adhesion. It is important that each printed layer is able to harden when poured and hold its self-weight. Although, it shouldn't become a separate entity [51]. All parameters are dependent on state parameters of concrete in its fresh state. The shear stress, viscosity and thixotropic behaviour of the concrete need to be researched [44].

As soon as the extrusion of the fresh material is successfully executed, the material properties in the hardened phase need to be researched. The structural properties of the hardened con¬crete are influenced by the strength (both com¬pressive and tensile), shrinkage and ductility [52] [49]. The influence of these parameters may cause cracking of the concrete if not considered carefully. In order to control these parameters, and improve on the workability of the material, the printable mixture may be complemented with additives like aggregates, fibers, rein¬forcement and chemical additives (figure 4.3e). A better bonding by means of additives allows for achieving specific properties such as a high strength and a certain level of ductility [44]. If successfully executed, a concrete structure in its hardened state can have similar strength and density as cast concrete [53]. A success¬fully 3D printed concrete structure will remain a well-considered balance between all men¬tioned parameters in both the material's fresh state and hardened state.

Fig 4.4: Topology optimized bridge by the University of Ghent [54]

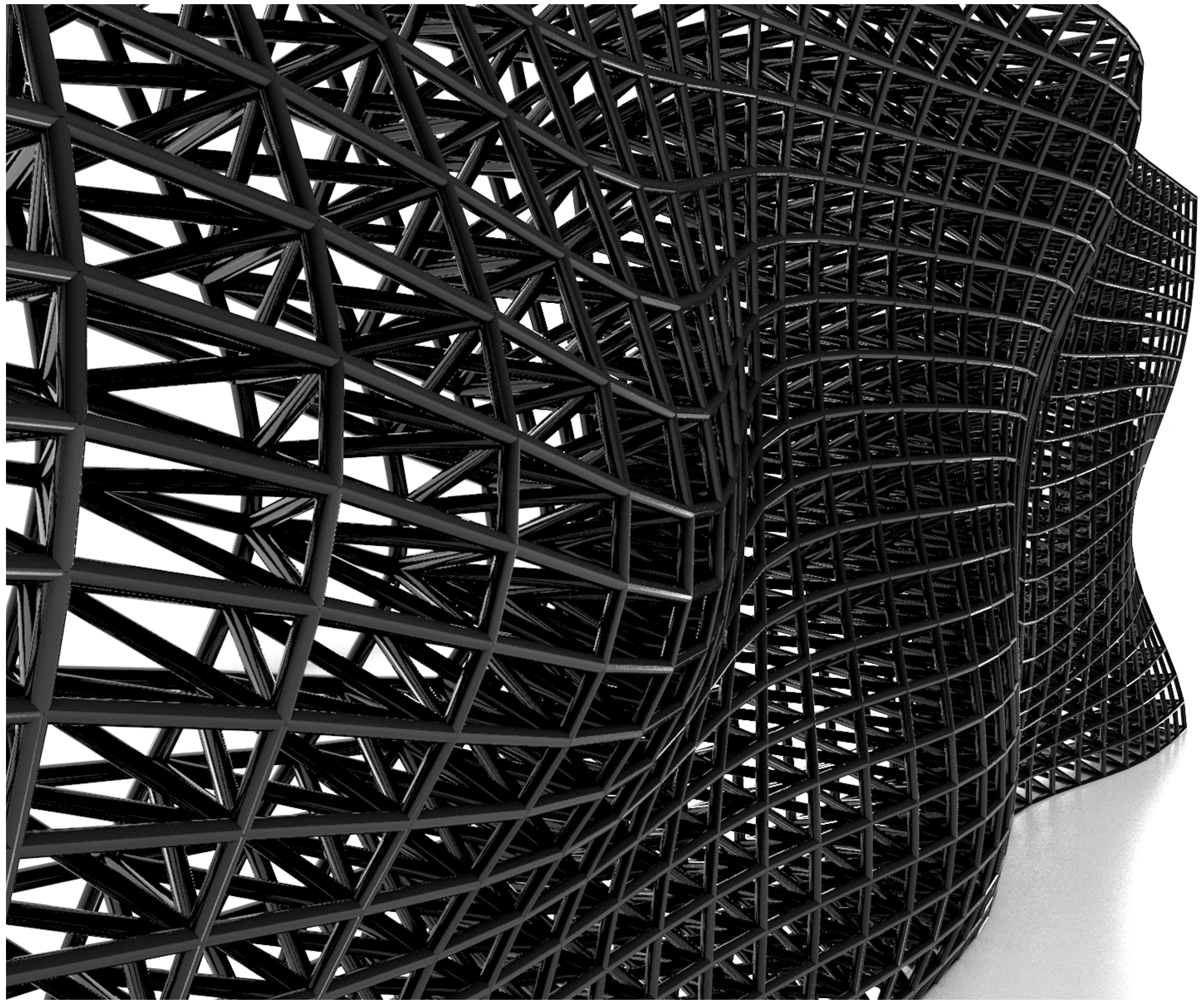
DESIGN METHODOLOGIES

OPTIMIZING TOPOLOGIES
The method of optmizing topologies is opening new doors in relation to design, for example the 3D printed bridge by Vertico, shown in figure 4.4 is designed in accordance to the method of topology optimization which provides a freedom for structural designers who can now be more innovative with their structural lay-outs etc. A big advantage of this method is the way in which the material and weight can be reduced com¬pared to how products would traditionally be designed.

COMPLEX GEOMETRIES
3-D printing is an additive manufacturing (AM) technique for fabricating a wide range of struc¬tures and complex geometries from three-di¬mensional (3D) model data. For the construction industry extrusion based prosses could be extremely beneficial in the field of freeform constructions. The maintenance of high degrees of geometrical freedom, is a recurring theme. [36] By means of 3d printing, the complexity of a part is no longer determined by the production process but by the desired design and functionality of a product. Complex geometric parts that previously could not be produced with conventional techniques such as milling, turning and casting are possible with 3d printing.

With the possibility of 3d printing, any subject that can be constructed in a 3D CAD program can also be produced. There are hardly any limitations. It gives designers maximum design freedom

DIGITAL MANUFACTURING
MORPHICS



The image above shows a double curved wall that is translated into a printable (plastic) mesh that might serve as the formwork for an otherwise difficult to engineer wall element.

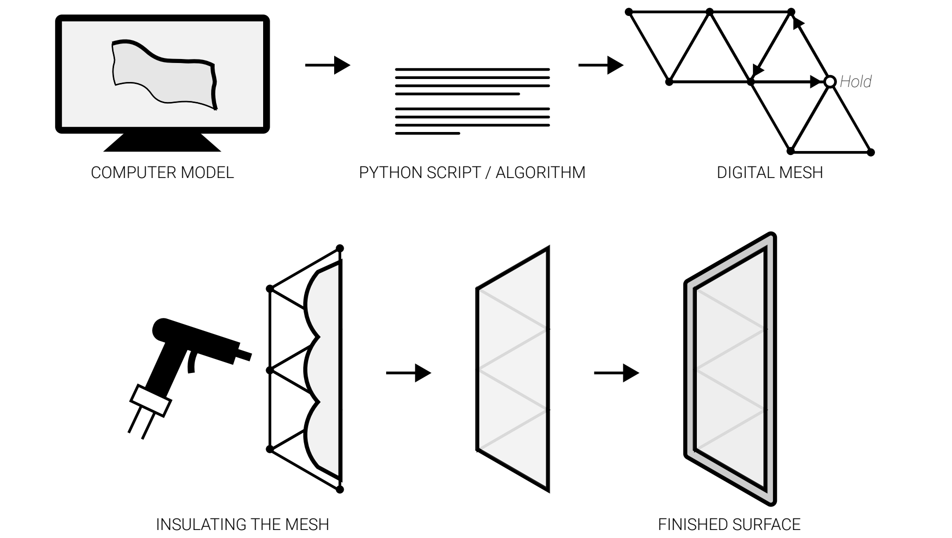
INTRODUCTION

This part of the research is a collaborative effort from Roy van der Heijden, Michiel Peeters and Jorn van Wegen as a deeper research into the field of digital fabrication as a part of the Big House Graduation Studio, under the supervision of Zeeshan Ahmed and Christina Nan.

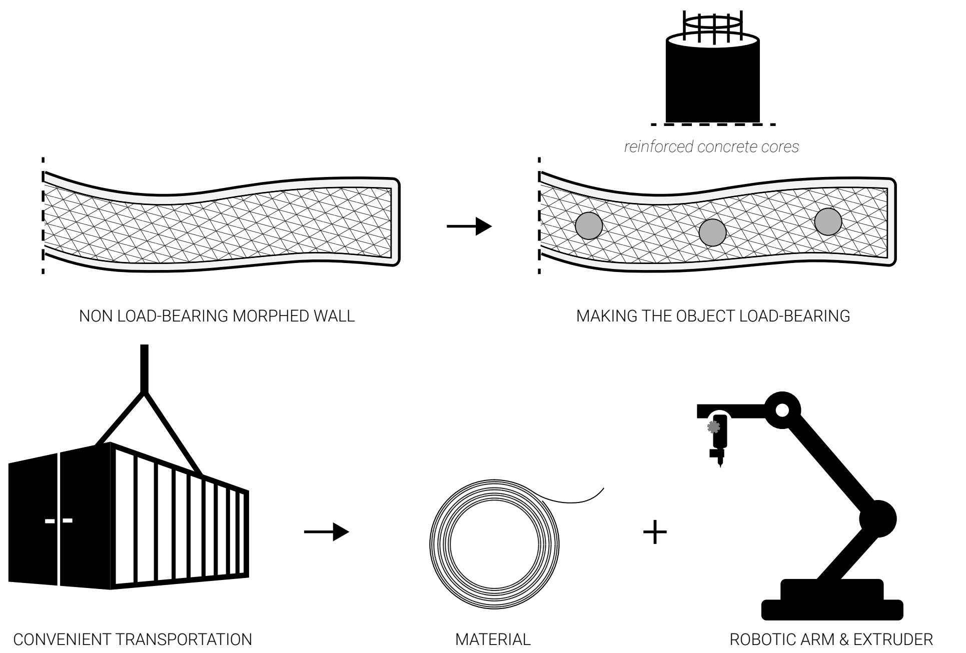
In the first half of the chapter on digital manufacturing, the state of the art of digital fabrication in the construction industry has been expounded. One of the techniques that is currently emerging within the construction industry, but which has gotten little attention in the exploratory research, is the digital fabrication of meshes as a way of creating formwork for difficult to produce concrete elements. This way of digital fabrication offers an entirely different angle, and various advantages over the standard extrusion based printing of cementitious materials on which most 3D printing techniques within the construction industry are based.

This technique was further explored in a collaborative effort from Roy van der Heijden, Michiel Peeters and Jorn van Wegen to produce the Morphics 3D printing technique. As a group, efforts were made to improve current technology and to combat the various challenges that this technique still faces.

DIGITAL MANUFACTURING
MORPHICS



The Morphics fabrication sequence. A computer model of a complex object in translated to a printable mesh that acts as the formwork for infill material.



A possibility to making the Morphics elements loadbearing & the advantage of the extremely light weight construction of Morphics.

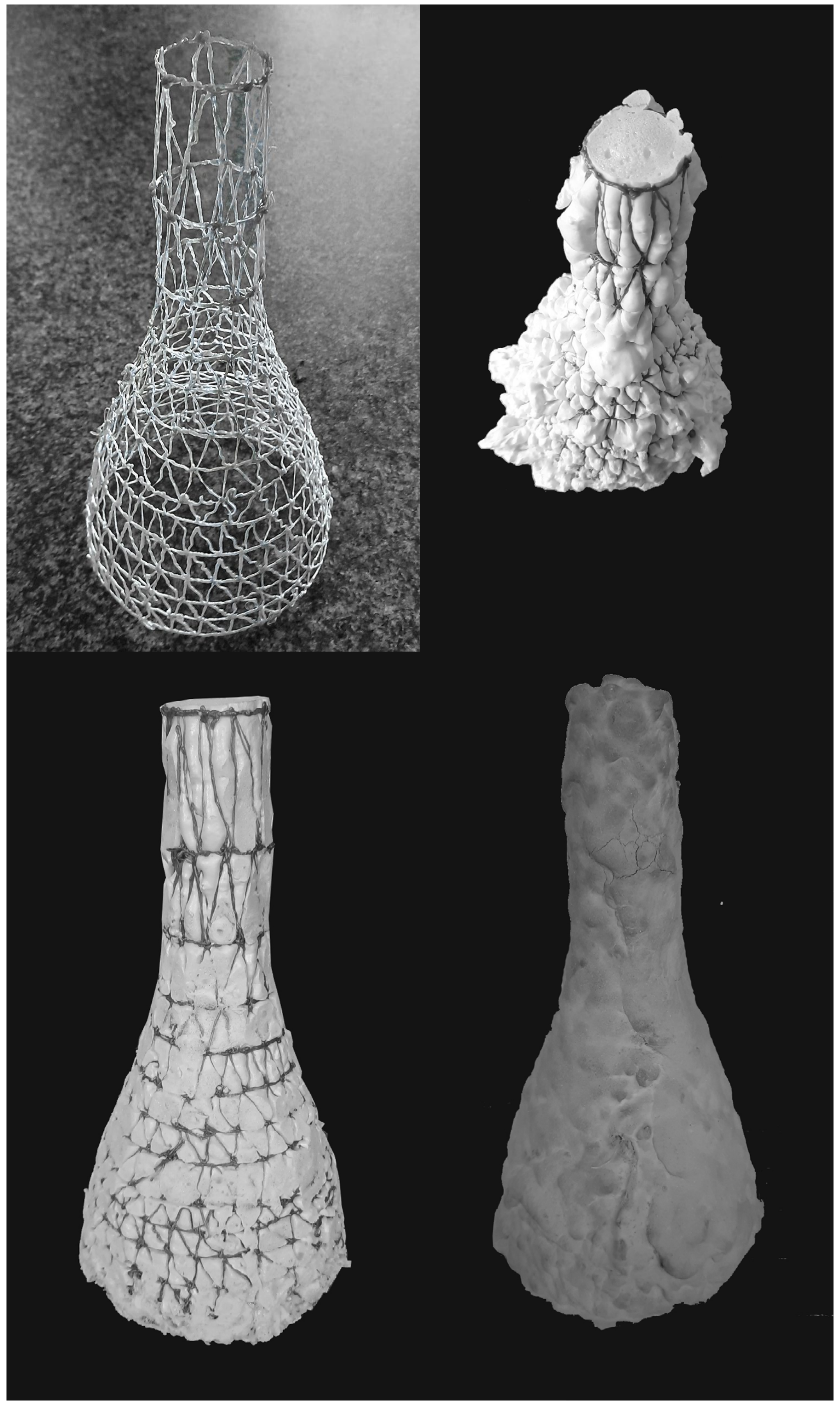
CONCEPT

The Morphics technique basically works as follows: a computer model of a complex element is produced, which will then be turned into a printable mesh by a certain algorithm. This algorithm 'draws' this mesh in such a way that it can be printed by a robot arm in a single go. For this to happen, the mesh needs to be drawn by the algorithm as a single, continuous line. This is called a toolpath. More on this topic will be discussed later on.

Once the toolpath has been produced, a robot arm with a plastic extruder can produce the mesh, and turn the computer model into a physical model. Here is where one of the main advantages of the Morphics technique comes in. Instead of filling the resulting mesh entirely by using a concrete mix with a low viscosity, like how it is mostly done in practice, it will be filled using insulating PU foam. The surface is then finished using stucco or cement. The result is a self-supporting insulated, which is incredibly stiff due to the combination of the printed mesh and the now hardened PU foam. On top of that, the element only needs a thin layer of finishing on the inside and outside, resulting in very thin wall elements.

This then also produces the main challenge of the Morphics technique. The resulting elements are self-supporting, and not loadbearing. One of the ways to solving this, might be by introducing loadbearing cores to the Morphics elements, as shown in the image on the left. This concept has yet to be tested in a later stage of the project.

Due to the fact that the Morphics technique produces extremely lightweight elements, one of its other main advantages is the convenient transportation. This holds true both for prefabricated elements, as well as for production on site, as the needed machinery and materials are relatively lightweight as well.



Upper left: the mesh that was produced with a 3D pen, using a vase as support. Upper right: the mesh fillled with sprayed PU foam. Lower left: the foam has hardened, and excess foam has been cut away. Lower right: the concrete flnishing has been applied.

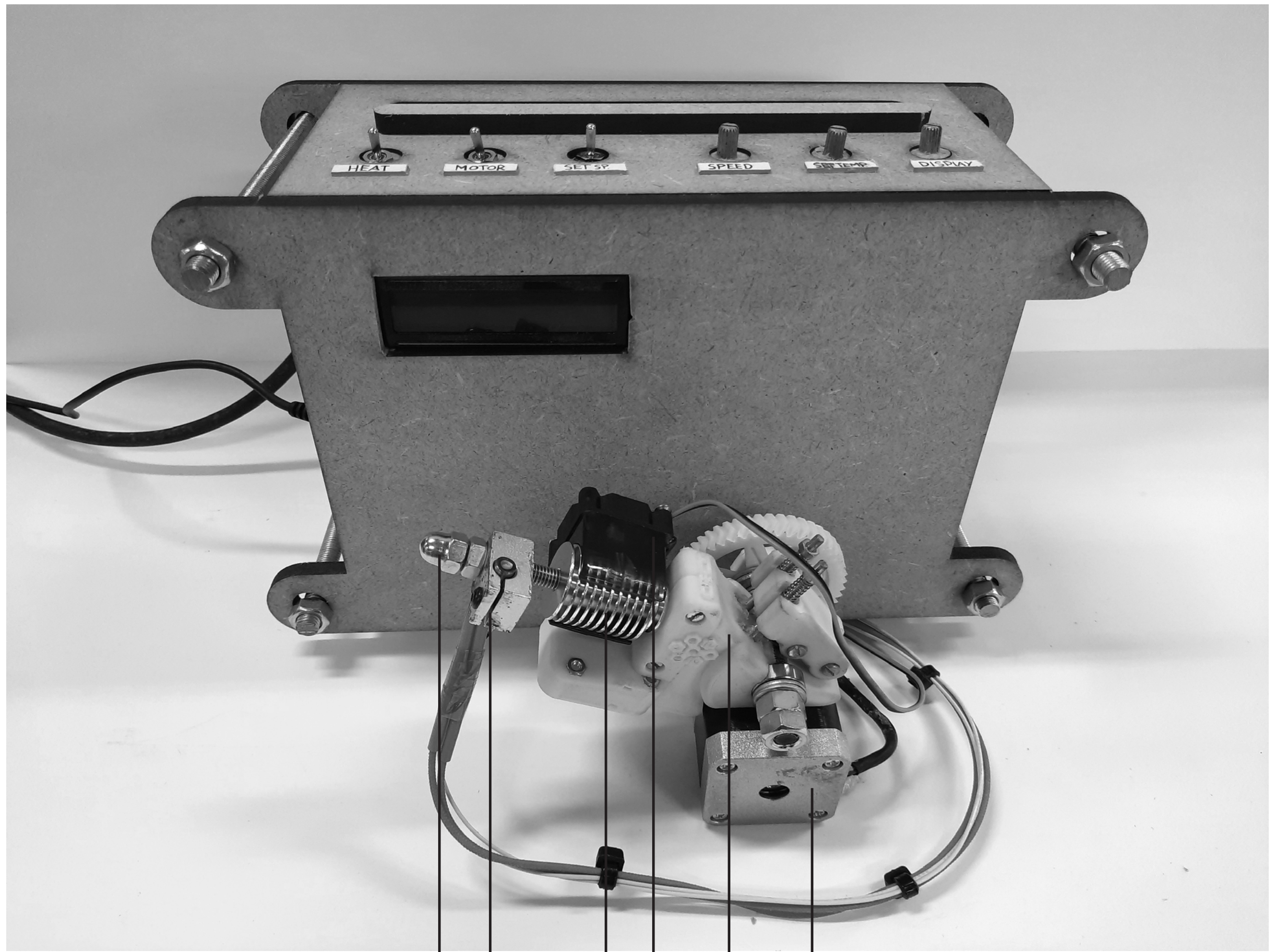
FIRST EXPERIMENTS

One of the first experiments with the Morphics technique was done using a simple 3D plastic printing pen. The used pen is the 3D Print Pen Pro from 123-3D.nl. The pen is not quite good enough to truly print in three dimensions without the use of a support structure. In this experiment a vase was used to trace in 3D. The resulting plastic mesh is not very stiff or strong, but it is a good enough formwork for the insulating foam. The PU foam is applied using a spray.

Once the foam was hardened, the combination of the plastic mesh and the insulation became relatively stiff and strong. The excess foam was cut away using a knife.

As a last step, concrete was applied as a finishing surface. The concrete that was used had a low viscosity, but due to the fact that the cement was in essence an egaliser, it did not yet yield the hoped result.

An effort has to be made to find the right ratio between the right kind of cement, sand and water to get a smooth surface and a material that is easy to apply as well. Ferrocement is sometimes used in similar construction techniques to do just that. Another option might be to use sprayed concrete to finish the object. If the Morphics technique were to be combined with the spray printing technique as has been discussed in this research, the whole process could be automated.



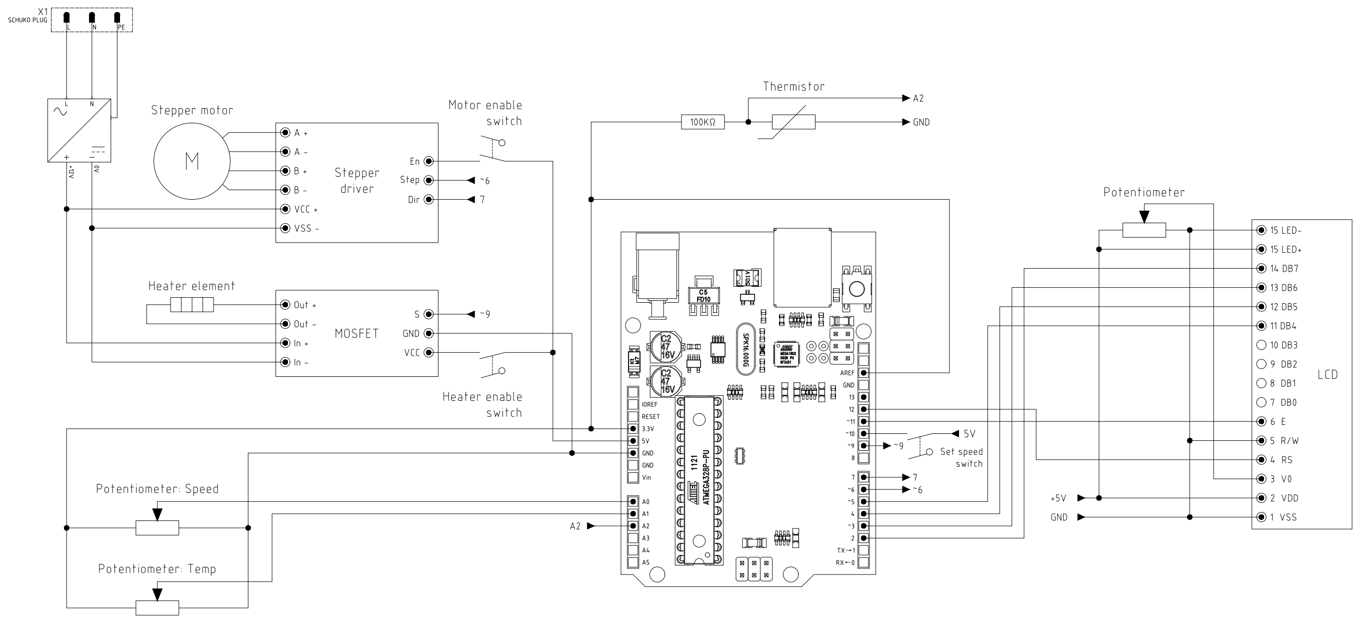
The first version of the extruder. The electronics are in a timber laser-printed box. All elements of the extruder itself are ready made, store bought elements.

THE FIRST EXTRUDER

After the experiment with the 3D pen, it became clear that a more professional approach was needed to the printing of the mesh aspect of the project. An extruder was designed using components that can be bought online. The hot end, which consists of a heat block that heats the material, a nozzle of 0.3mm and a heat break that is cooled using an ventilator was bought as a whole package. The cold end was 3D printed using the Infill 3D 75 Geared Extruder Model designed by Infill3D on Thingiverse.com. A stepper engine is used to feed the material to the hot end.

To get the components to work, a stepper driver is needed for the engine, a mosfet is used to drive the heat block, and Arduino Uno and display are installed in the electronics box. With the box, the temperature of the heat block and the speed of the engine can be controlled.

For a complete overview of the electronics, see the schedule on the next page.

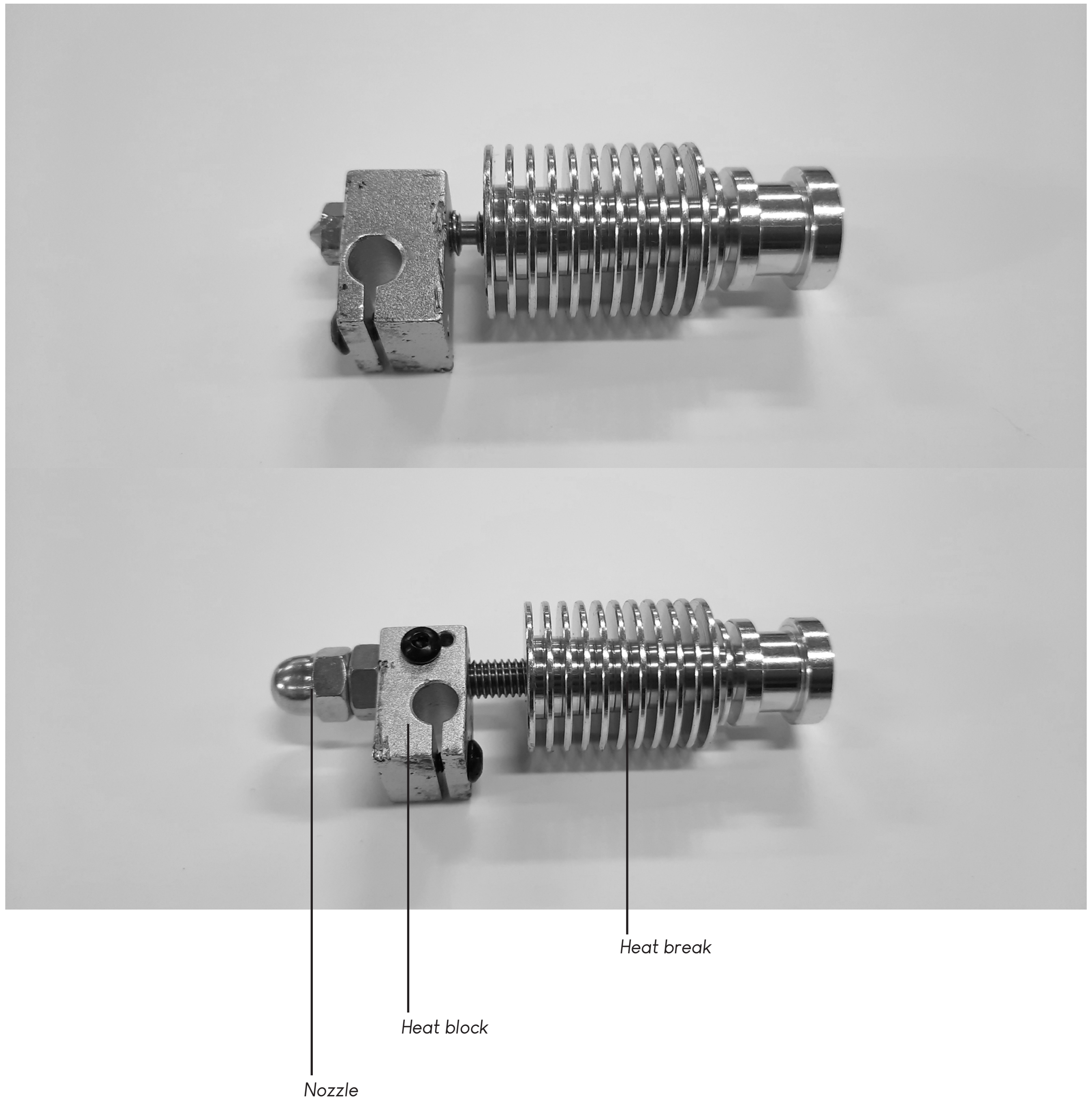


The schedule of the electronics behind the extruder.

THE FIRST EXTRUDER

On the left page the electronic schedule of the extruder is displayed. In the end, another mosfet and heater elements were added to the extruder, which are not included in the schedule.

Special thanks to Mark XXX who helped engineer the electronic side of the project, and helped make this project possible.

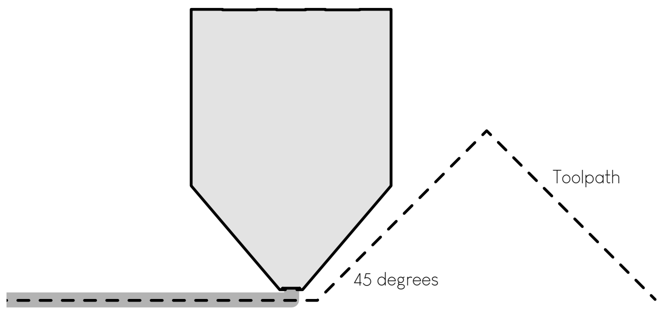


The initial nozzle as it was ordered, and the custom tapered nozzle that would solve the issue for 3D printing meshes.

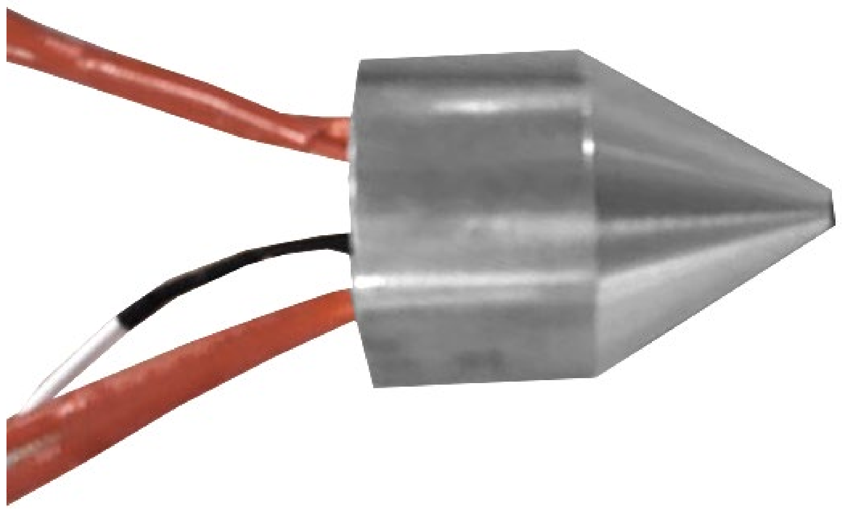
THE FIRST NOZZLES

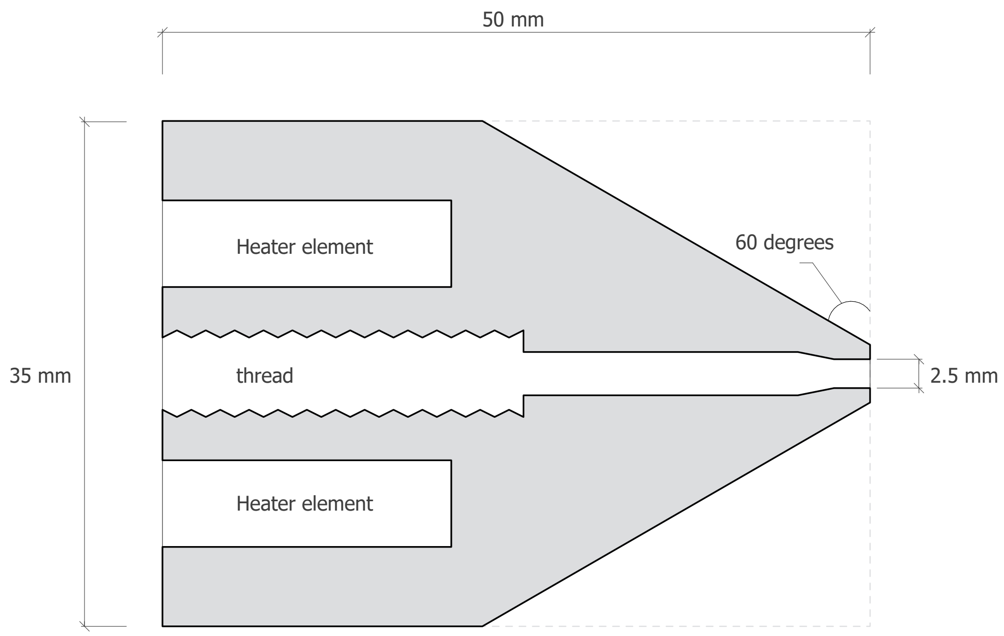
Once the initial version of the extruder was finished, the time came to start customising it to fit our purpose. The first challenge was to create a nozzle. The nozzle that was provided with the hot end (upper image on the left) does not work properly when printing meshes in 3D. The schematic image below will make clear why. The nozzle needs to be tapered towards the end, so that it does not touch the mesh lines that is has already printed by pushing through then again.

The provided nozzle was made out of brass, so that is what we used to create a new nozzle, as it is a good heat conductor. However, it soon turned out that the new nozzle did not work as intended. The heat block was not strong enough to keep the plastic melted until the tip of the nozzle, and the heat conducting properties of the brass were apparantly not that great.



Special thanks to the Vertigo workshop employees at the TU/e who helped design and construct the custom nozzle.





The new custom nozzle. Longitudinal heating elements have been placed paralell to the material feeding direction.

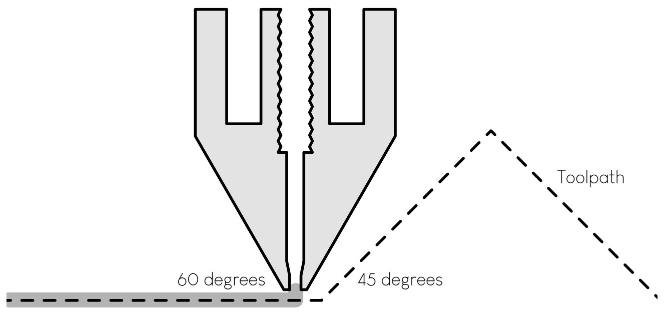
CUSTOM NOZZLE

After the initial nozzle and the second version of the nozzle did not work, it was concluded that a custom-made nozzle was needed to make the extruder work for its intended purpose. For this new nozzle aluminium was chosen as a material, instead of brass, because of its superior heat conducting properties. A rod with a diameter of 35mm and a length of 50mm would serve as the base component.

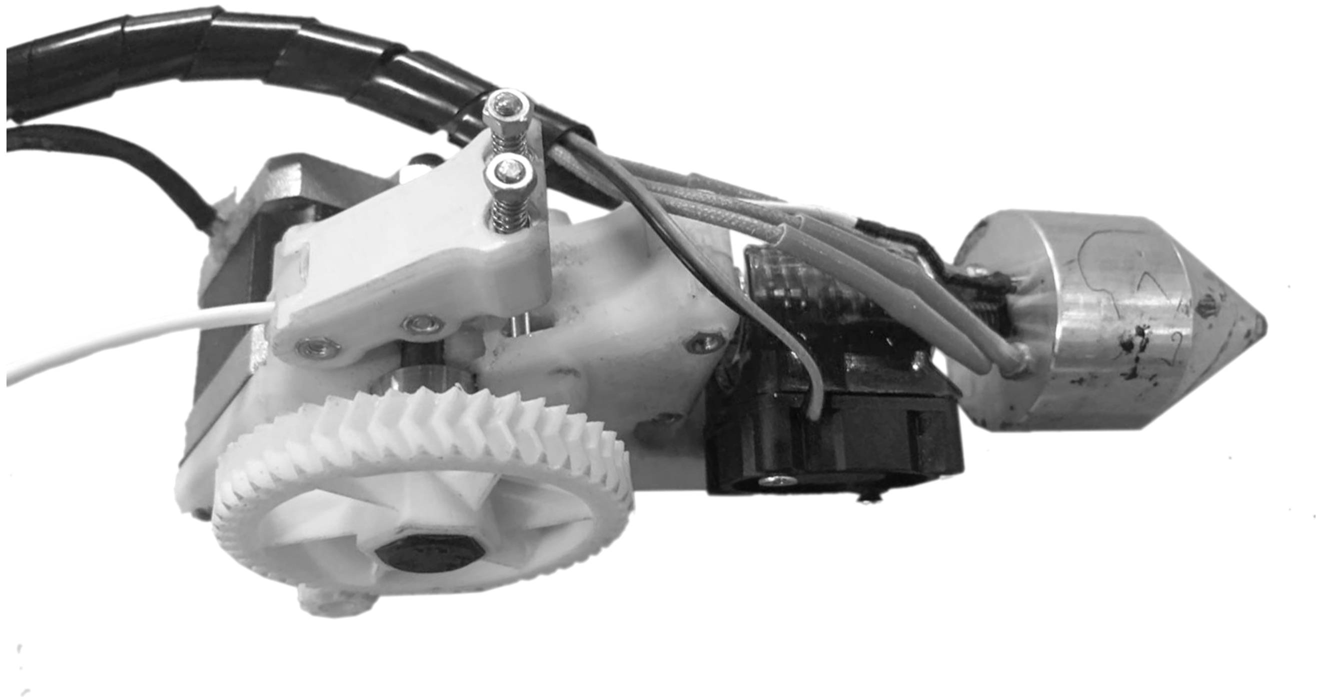
Through the middle, a hole was drilled of 3mm, which would be able to feed the filament that has a diameter of 2.85mm. At the end, however, this hole would tighten to 2.5mm so that the melted filament would be pressured out of the nozzle. The first half of the nozzle was then made wider and fitted with thread, so it could be screwed onto the brass feeding tube. An important improvement of this nozzle is that the heat block is no longer a separate element, but rather the whole nozzle serves as a heating block. Two heating elements are placed paralell to the feeding direction, to ensure a more efficient and stronger heating of the filament.

The nozzle itself is tapered to 60 degrees, so that it is sleek enough to never touch and destroy filament that has already been printed. This also means that when needed, the mesh can now also be produced with angles of 60 degrees instead of 45 to ensure a higher stiffness of the structure dueo to more deposited material.

Another small hole has been drilled into the custom nozzle where a thermometer is placed so that the temperature of the nozzle can be accurately measured and adjusted.



Special thanks to the Vertigo workshop employees at the TU/e who helped design and construct the custom nozzle. Extra special thanks to Frank, who spent multiple hours tapering the aluminium nozzle.

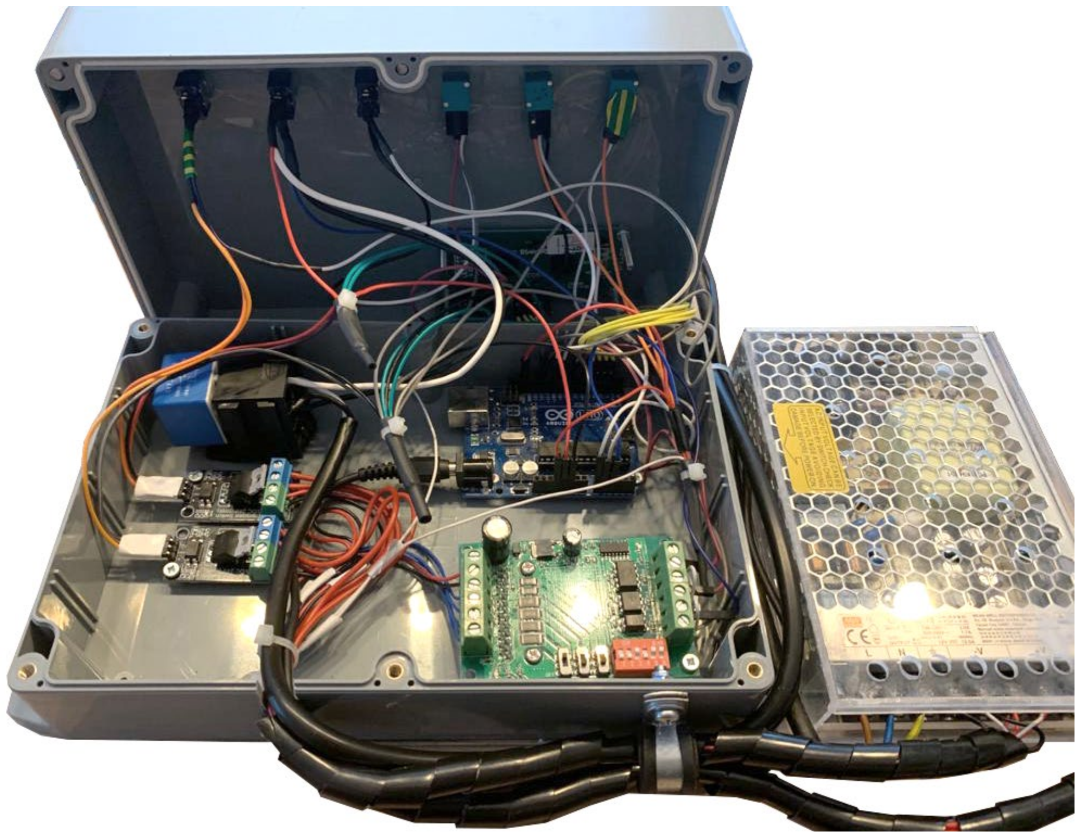


The finished custom extruder as it was used during the first promising experiments.

THE FINAL EXTRUDER

On the left the extruder is shown in its final form. The custom nozzle is fitted, and the 3D printed cold end of the extruder has been adjusted so that it feeds 2.85mm filament, instead of the 1.75mm filament it was initially intended for. The choice to switch to the larger filament was made after the initial artefacts that were produced with the original nozzle were assessed. The objects were very fragile, and thus was decided that thicker mesh thread was needed to give the mesh its desired strength en stiffness.

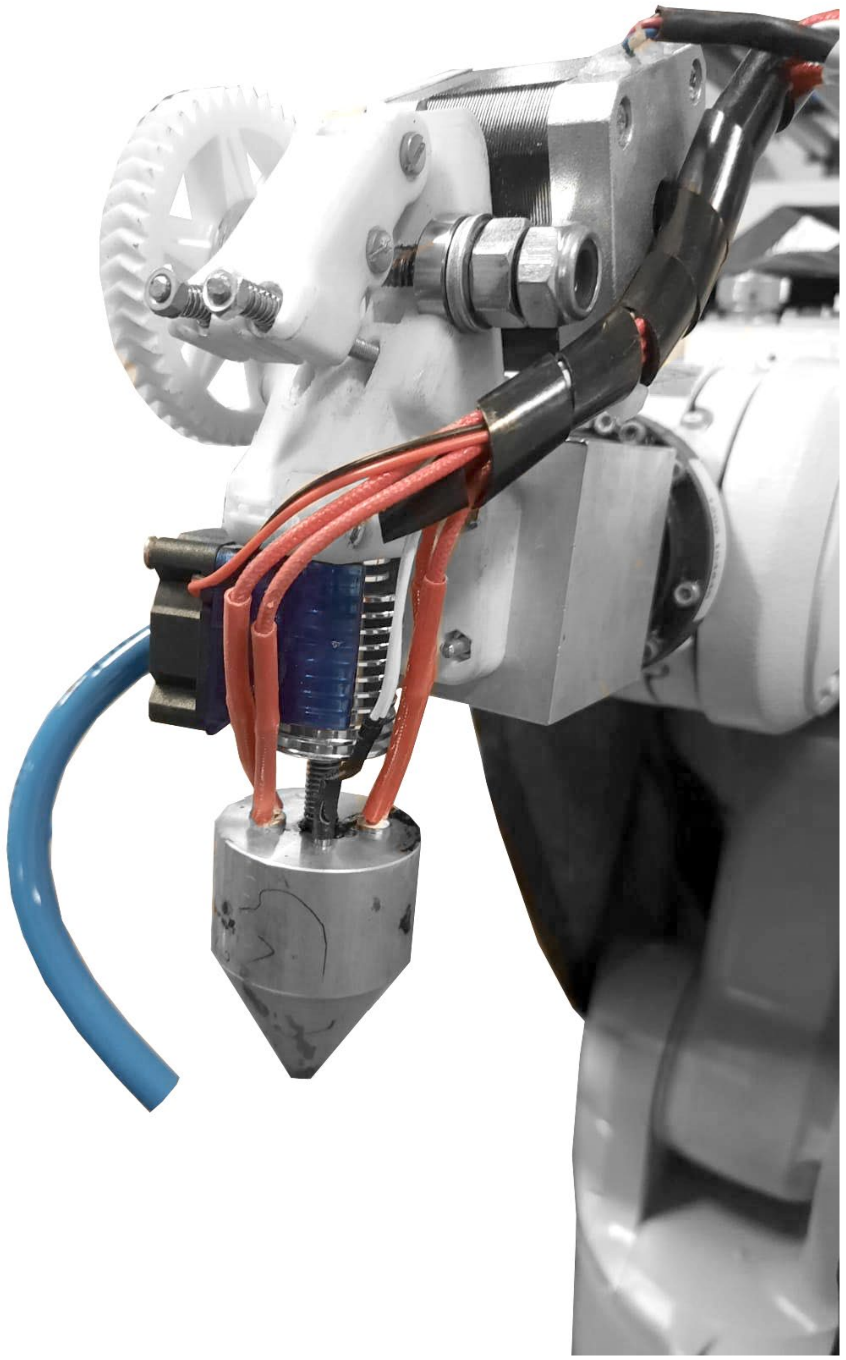
THE FINAL EXTRUDER



The new casing for the electronics. Various safetey measures have been implemented to this new casing design, as the old one was nowhere up to standards.

Once the extruder was finished, the electronics were updated to match the new components and changes that were made. The casing was updated to be able to implement various safety measures. The power supply was separated from the rest of the electronics, and the switches were fitted.

Lastly, a remote switch was added so that the whole printing process can be stopped from a computer, so that it could be integrated with the robot arm.

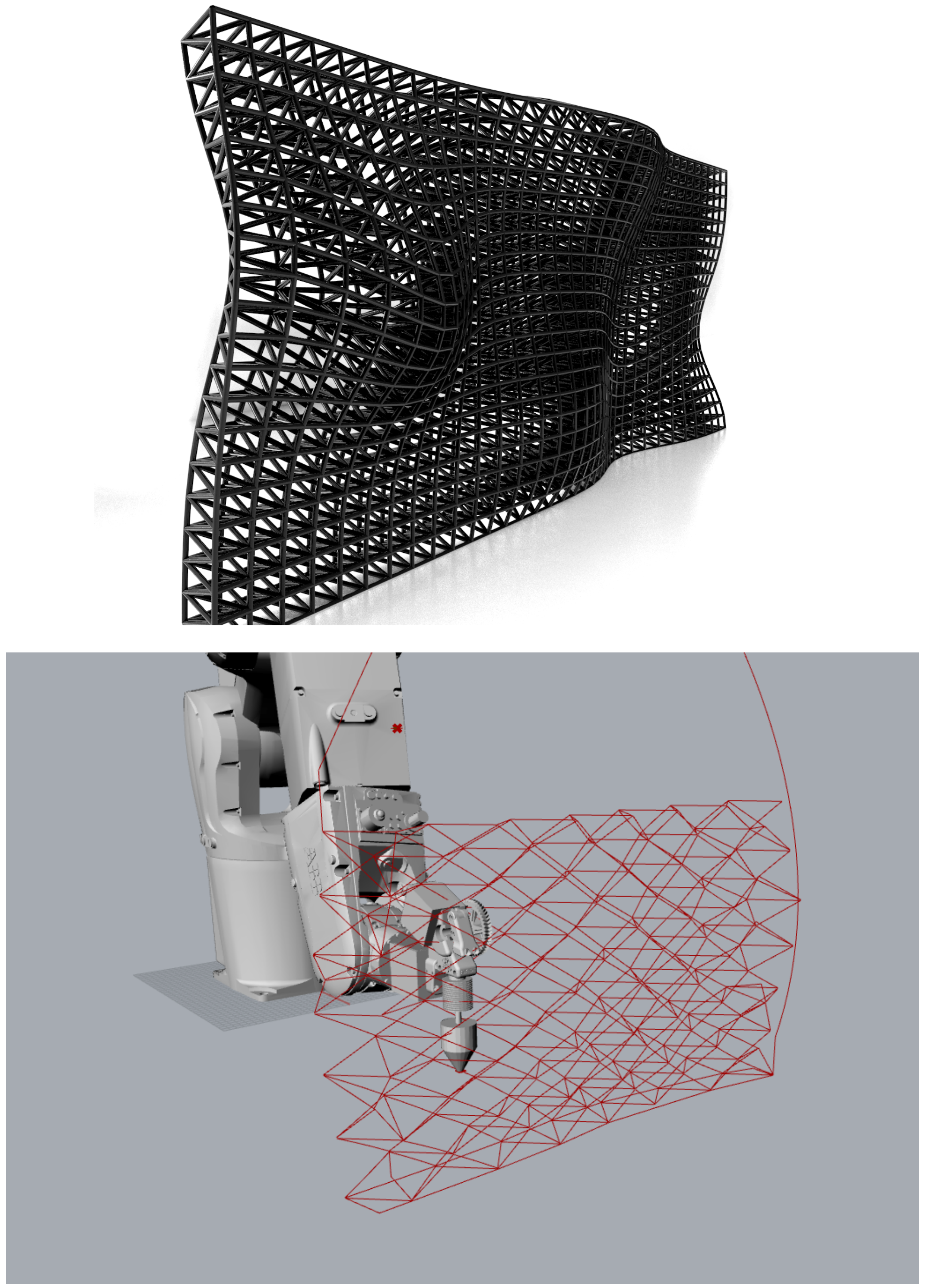


The extruder is fitted to the robotic arm, and a pressurised air flow is added to cool the filament once it has been printed.

THE FINAL EXTRUDER

After the completion of the final extruder, a first attempt was made to couple it to the robotic arm at the construction lab in Vertigo at the TU/e. A pressurised air system was added to the extruder. The air flow is directed just below the point of the nozzle, so that the extruder material cools down quickly and allows the material to be printed in 3D. After the first try-out it was soon concluded that a more optimised system might be needed to do the job as intended. The idea is to subdivide the airflow into four new airflows that come from four different directions of the nozzle. That way, the material is cooled down from all directions, and is not being blown away.

Special thanks to Arjen Deetman who helped design the program of the script for the robot arm at the TU/e construction lab that was used.

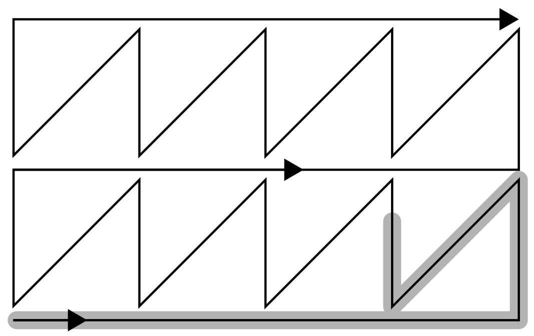


A mesh of a double curved surface, & the first toolpath for the robotarm.

THE TOOLPATH

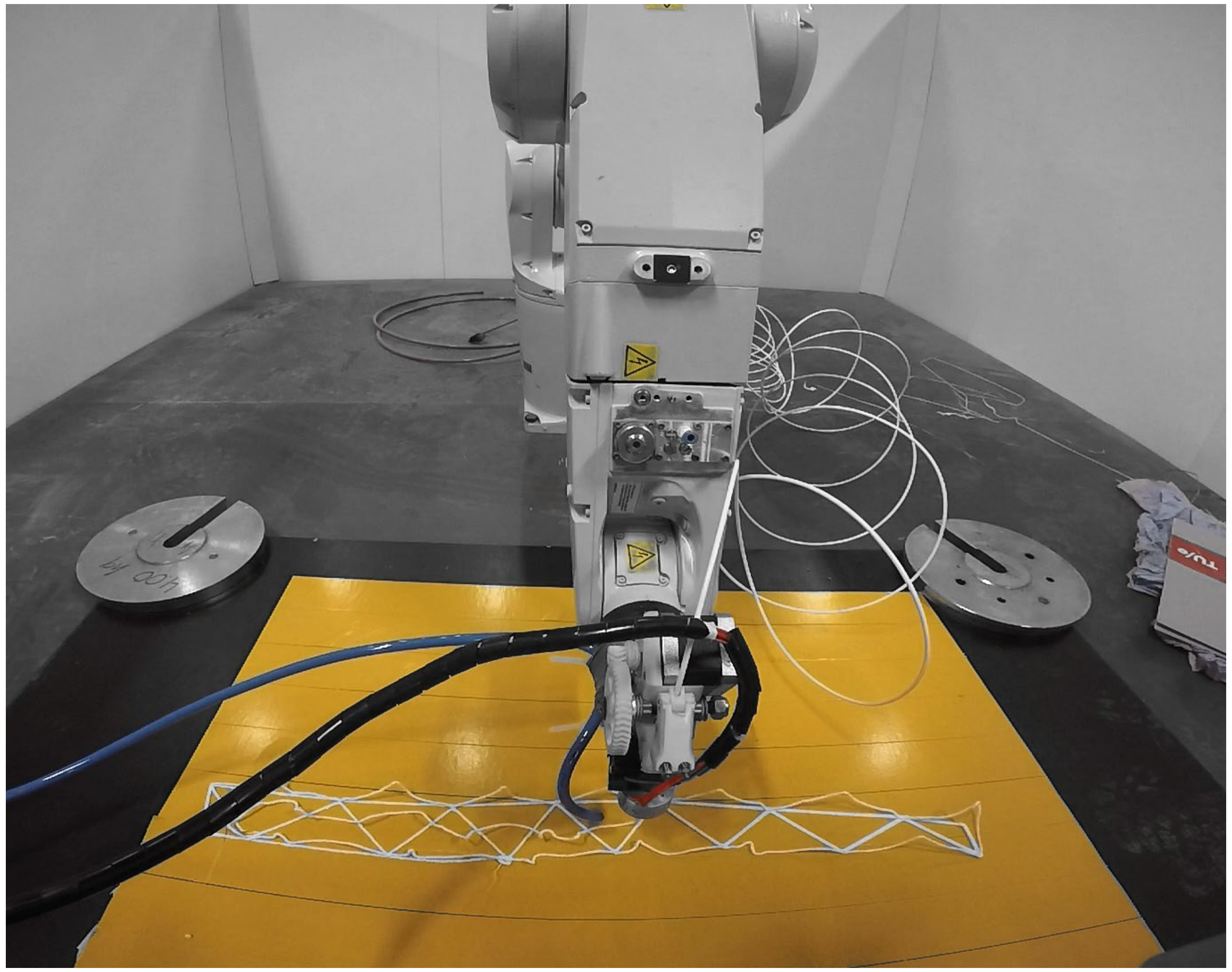
As was shortly explained in the beginning of this chapter, a good algorithm is needed which turns a complex surface, or object into a printable mesh. The difficulty here is that his mesh that is produced needs to consist of a single continuous line that the robot arm can follow.

In Rhino and in Grasshopper, there are plugins that can produce such a mess, as can be seen in the first image on the left. Here, a simple double curved surface is simply translated into a mesh. However, this mesh is not formed from a single line, but rather from hundreds of lines, which is impossible for the robot arm to read. Besides, even if it was a single line with a directional input for the robot to read, the nodes would ruin the final product once it is being printed. The problem is that the tip of the extruder would follow the line exactly, but the deposited material has a certain thickness. This means that the nozzle would keep on hitting the printed material in the nodes. The toolpath that the robot needs to follow should therefore stop about 1mm above and next to each node, as illustrated below.



This is unfortunately very hard to put into code, so for the time being all objects have been manually drawn. The toolpath on the lower side of the left page shows the first experiment that was done. A simple double curved wall has been translated into a mesh that could be printed by the robot by hand.

The toolpath was created in Rhino, and was imported in the grasshopper script for the robot. This grasshopper script was then fed to the application RobotStudio, which was used to drive the robot arm.



The printing of the first toolpath as designed for the robot arm.

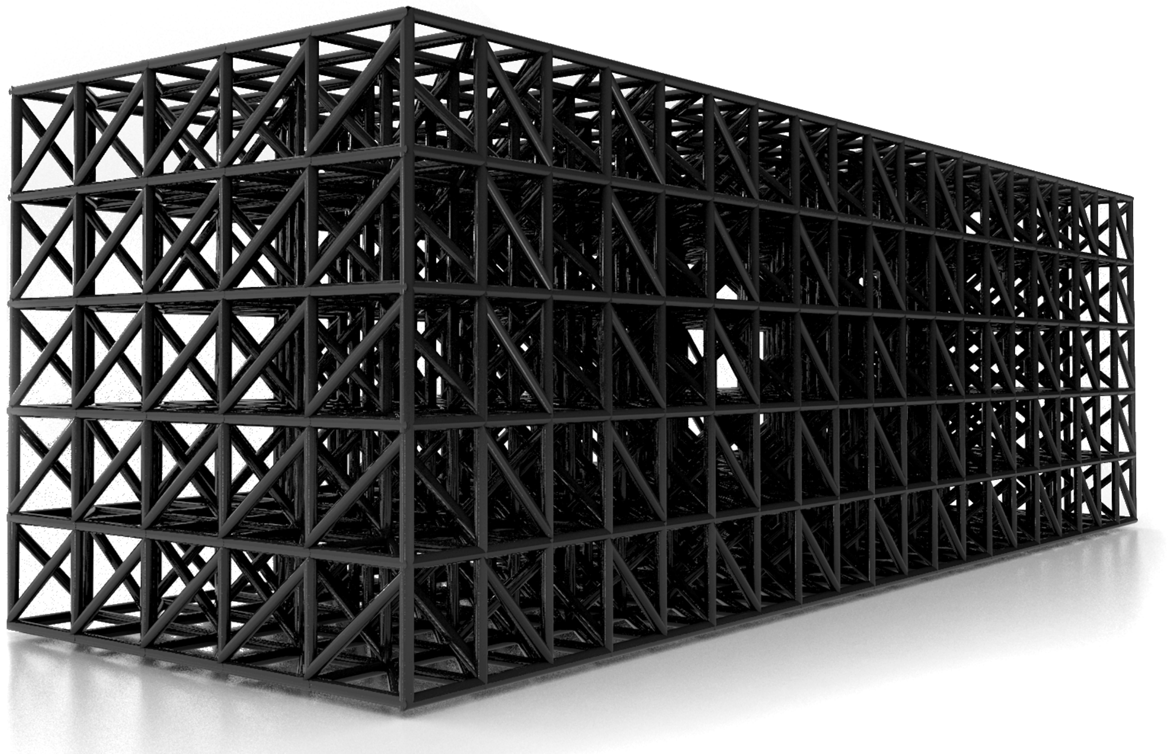
THE TOOLPATH

The image on the left shows the robot arm with the extruder in action. The toolpath as it is shown on the previous page is being printed here. It soon became apparent that the spans of the material were too great. Some of the single mesh lines are about 50mm long, which the material could not support.

It also became apparent that the air cooling of the printed material was not quite sufficient, as has been explained previously.

During the session the various printing speeds, robot arm speeds, and temperature settings were tested and determined for future tests.

The surface on which is being printed is covered in double sided tape. For this session the covering was not yet taken away, as this was just a test to see how everything worked. For the next test the covering will be removed, so that the mesh object will stick to the ground surface, and not accidentally shift during the printing session.



A simple brick of 300x75x90mm.

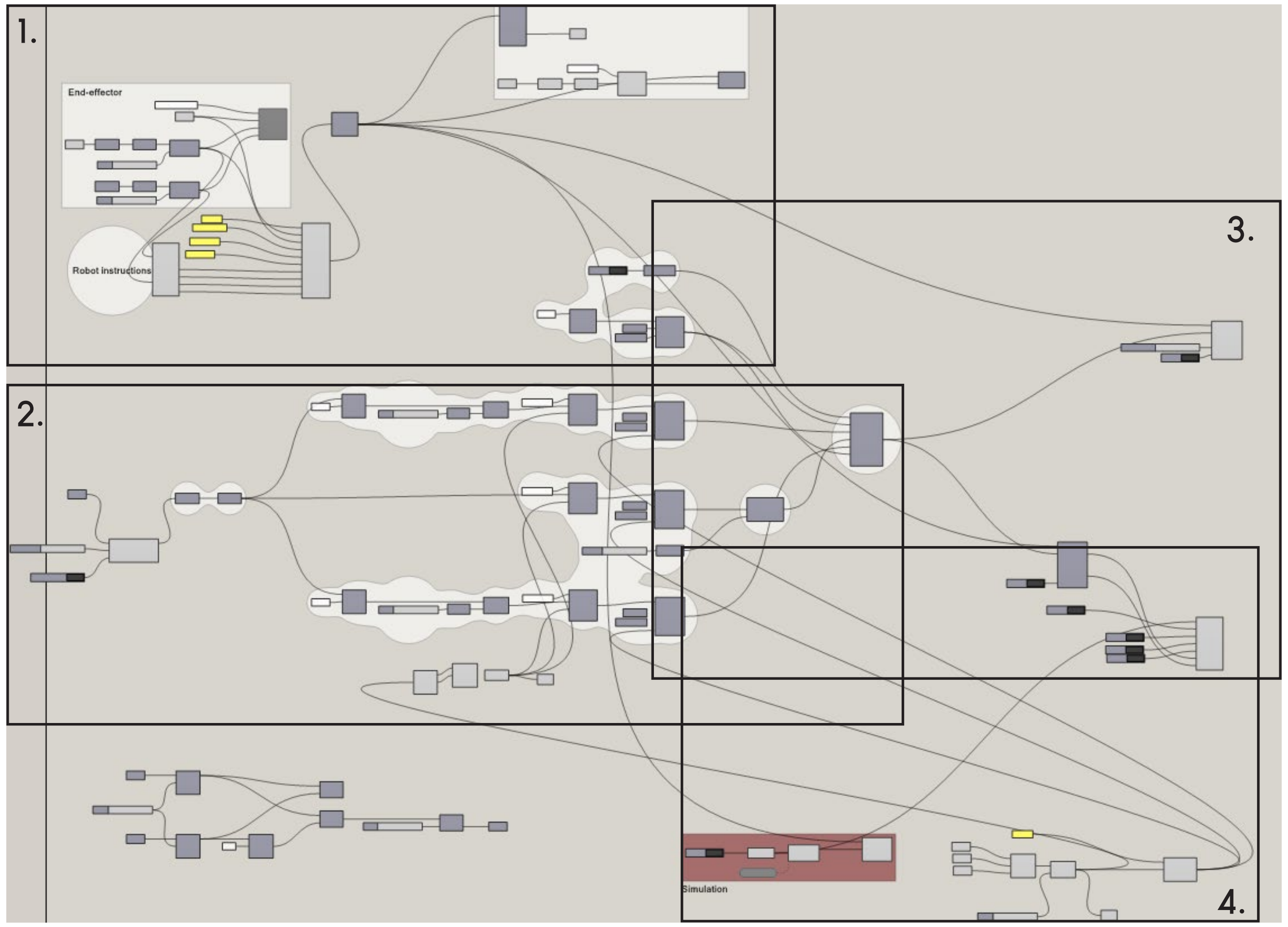
THE TOOLPATH

For the next experiment a new toolpath is created. This time the shape was kept relatively simple, as the line for the toolpath has to be manually drawn, and at this point the tests that have to be done do not depend on a complex shape.

The brick that is created measures 300 x 75 x 90mm. The span of a single line is no more than 23mm, and enough space is left between each of the nodes so that the nozzle will not touch already printed material. The goal is to print this shape with the settings that have been determined and the improved cool air flow.

Once the mesh brick has been printed, it will be filled with the foam, and finished with the cement. Various strength tests can then be performed on the brick. As a reference, a second brick can be filled entirely with concrete, as to test its performance compared to reinforced and un-reinforced concrete.

Unfortunatly, at the time of writing these experiments are yet to be continued due to the lock-down that the Netherlands is now in due to the COVID-19 pandemic.



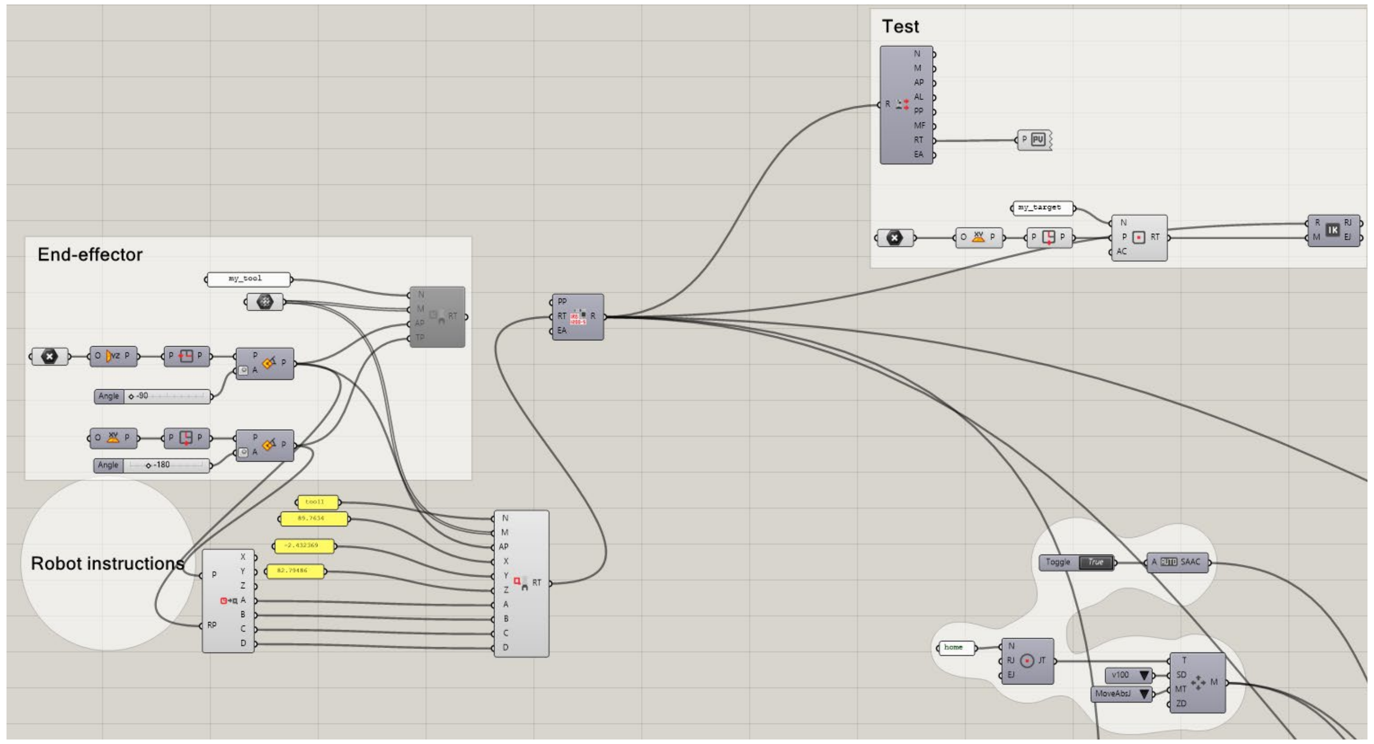
The Grasshopper script that is created to work with the robot.

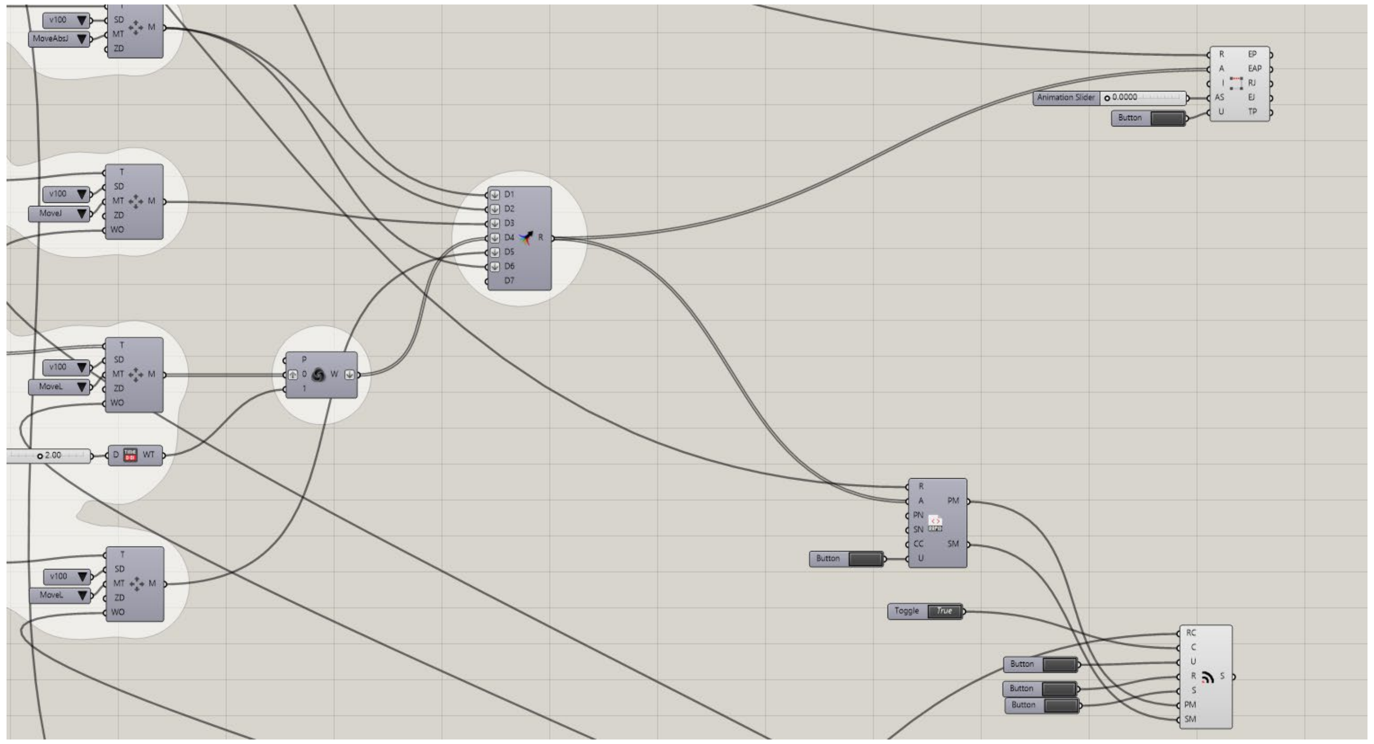
THE GRASSHOPPER SCRIPT

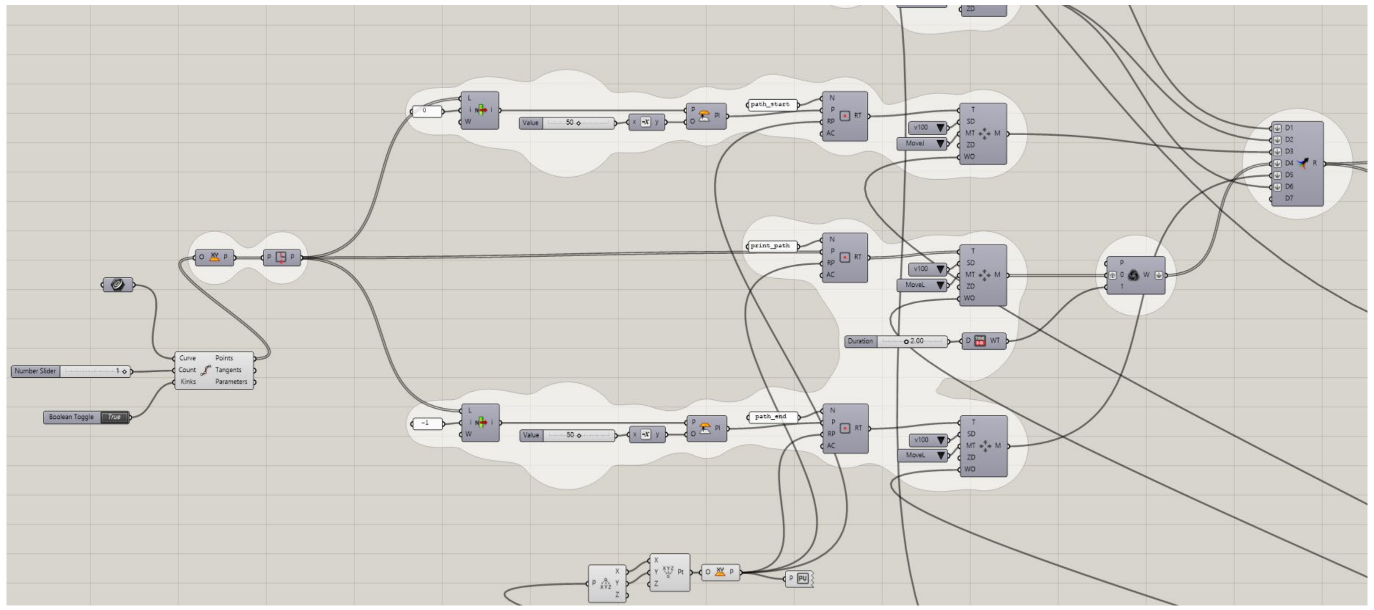
On the left the Grasshopper script can be seen that is used for the project. A detailed version of the schedule can be seen on the next page.

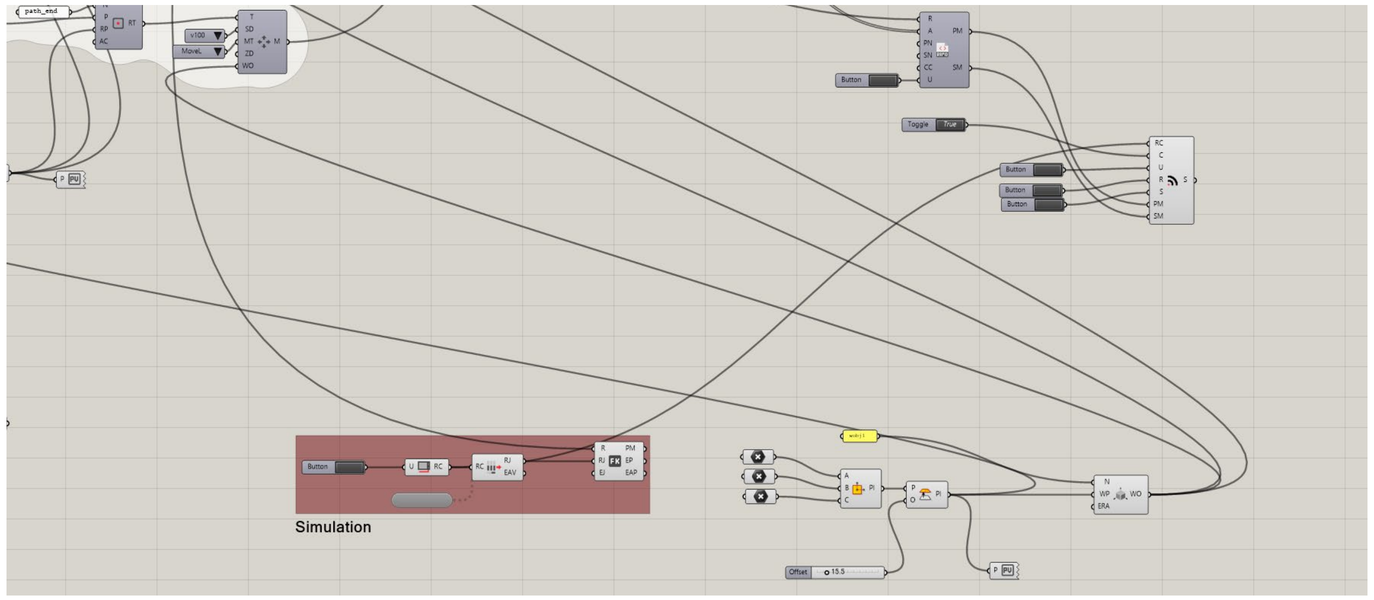
Special thanks to Arjen Deetman who helped design the program of the script for the robot arm at the TU/e construction lab that was used.

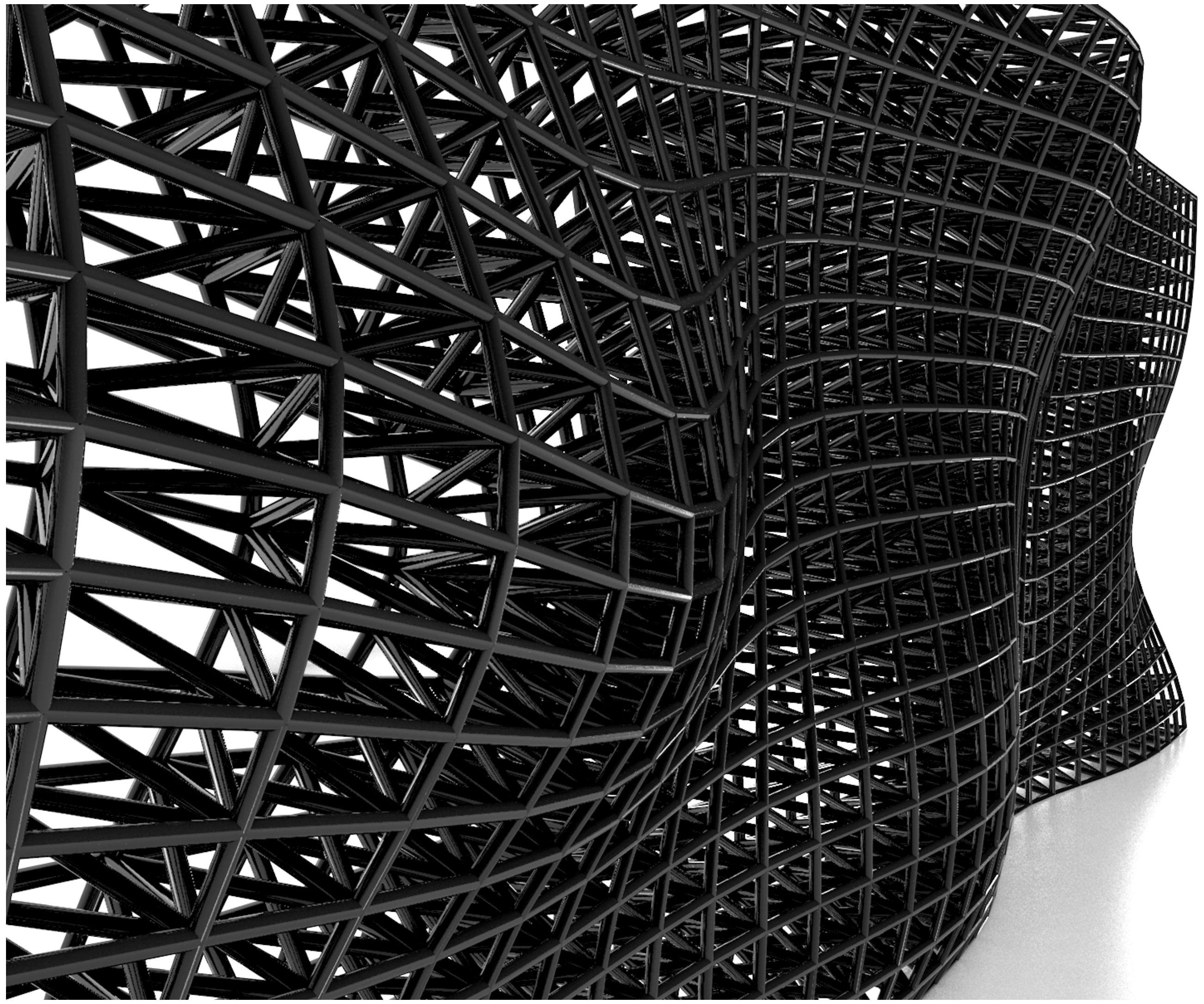
THE GRASSHOPPER SCRIPT











Morphics mesh wall.

CONCLUSION & DISCUSSION

Unfortunately, the COVID-19 pandemic has made this a very challenging project to execute. The time during the year 2020 that it was possible to work on the project on campus was mostly spent putting together a working prototype for the extruder, which in the end was completed. Unfortunately, due to new restrictions, it proved impossible to continue broadening the horizon of the technique of digital fabrication of meshes and combatting the challenges that the Morphics technique faces.

We do believe the Morphics technique shows great potential, and should continually be researched among the other techniques that pertain to the fabrication of meshes as formwork for the construction industry.

Especially the possibility of creating reinforced, load-bearing cores within the meshes shows great potential in real-world applications, and needs to be further investigated.

In the future, it is important that tests are done to determine the strength and stiffness of a mesh that is filled with insulating foam, to determine whether or not a real-world application of such an approach is feasible. Using the mesh simply as formwork for concrete to create complex non load-bearing objects has already proved to be feasible, but further research is needed to find out whether the Morphics technique is just as promising.

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PART III

REMOTE LIVING IN SCOTLAND

INTRODUCTION

As we have seen in the first part of the research, a turnaround in the way people perceive the city has taken place over the last century. Before, the city was seen as an unsanitary place where only the lower class workers would dwell out of necessity. However, a reappreciation for the city has changed this around. Through gentrification and various programs, the city has once again become a place where want to live, due to the abundance of amenities and the superior career prospects that city life has to offer.

This, however, means that people are leaving more rural areas for the cities, or at least for the peripheries of the city. This phenomenon is often called the 'rural flight' or the 'rural exodus', which is basically 'urbanisation' as seen from the rural perspective. Unfortunately, this rural exodus is starting to affect the communities that live more remotely. Many people living in such communities depend on a trade for their source of income. A trade that is often passed down to their children, who continue the business. However, more and more young people nowadays continue studying after secondary school, and often move away towards the city for their studies, and are then more inclined to stay for work once they do.

Though in the 1970s the trend of counter-urbanisation seemed to help repopulate these rural communities, it is observed that the bulk of these in-migrants belong to the wrong demographics to be able to grow and maintain the more remote communities. People that move away to such communities are often already retired, or close to retiring age, meaning that they contribute very little to the maintaining of such a commune. On top of that, it seemed that the counter-urbanisation trend has slowly died out, and even reversed in the more remote rural areas.

In Scotland, however, a small island named Ulva, which has been facing a decreasing population for centuries, has started fighting back. The island was recently bought by its inhabitants, and they are hoping to repopulate the island by launching various initiatives that they hope will attract new residents. They are looking for sustainable ways to maintain a healthy population that includes younger generations.

In this part of the research, the phenomenon 'rural exodus', and its counterpart 'counter-urbanisation' will be investigated first. The research will mostly focus on Europe, and then specifically towards the United Kingdom and Scotland. Effects of these trends on remote and rural communities will be analysed. After that, the concept of 'remote living' will be further investigated, to see what such a remote community needs to maintain itself. The island Ulva, on which the project proposal will focus, will be thoroughly analysed. Then a proposal will be presented to start the repopulation and revitalisation of the island of Ulva.

REMOTE LIVING

THE RESEARCH

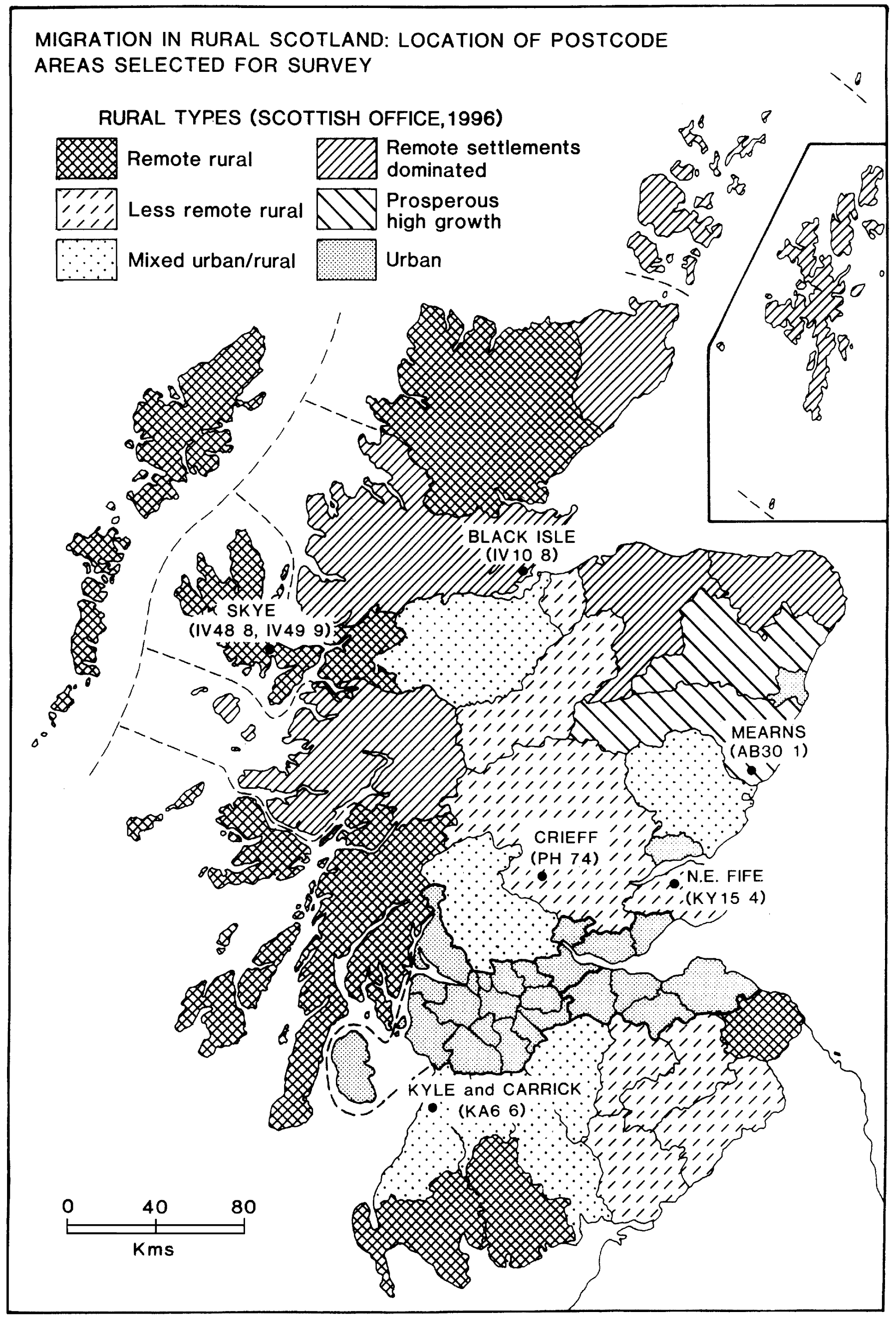
"How to revatalise and repopulate remote Scottish communities in a sustainable and future-proof manner?"

Research Question

Unfortunately, the more remote and more lowly populated areas of Scotland have only temporarily enjoyed the counter-urbanisation trend. Various remote communities of the Scottish Highlands and Islands are again facing a population decline with all that this implies for its remaining residents.

The question is what is needed in these remote living communities to revitalise them and help them sustain a self-sufficient existence that will attract new permanent residents? To this end, it is important to create tight-knit communities, but how does one achieve this?

Various current trends might act as a catalyst to achieve more populated remote areas, such as the surge in people wanting to live a sustainable life, and the possibility for more and more people to work from home, but how can one apply these trends and use them to the benefit of repopulating remote communities?



Rural and urban Scotland.
(Stockdale et al., 2000)

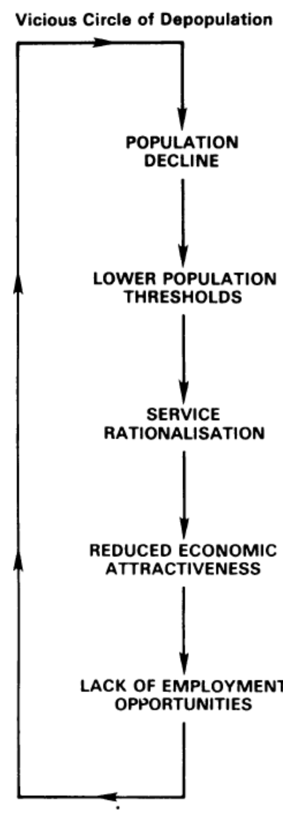
RURAL EXODUS IN SCOTLAND

In part I of the research, we have seen that rural areas are still a much preferred location for the wealthy to build their Big Houses, as a rural retreat. This however, is the opposite of how most migration patterns have manifested themselves over the last centuries in what one would consider to be "developed countries". People have been choosing the city over the countryside ever since the industrial revolution.

For much of the 20th century, depopulation and rural communities were two inseparable notions. Rural Scotland was not an exception. In fact, most of Scotland had been dealing with the Clearances* for most of the 18th and 19th century, which resulted in an already enormously depopulated rural Scotland.

For many of these remote communities this rural exodus had hard impacts, such as an ageing population that enjoys less local services. The older generations are left to reside in an increasingly emptied out rural environment, as the younger generations move on to better career prospects that the urban centres have to offer. This results in an increased poverty relative to national averages, and the demise of the primary sector as a major employer (Stockdale et al., 2000).

In fact, Wallace and Drudy (1975) identified a vicious circle many of these rural locations get stuck in by isolating several key causal elements that reappear in such communities. The main reason these communities get stuck in this vicious circle are the structural changes in traditional rural industries which prompt a decline in rural employment. The subsequent decrease in population then results in a lowering of service thresholds. As fewer services are demanded, the service levels will contract, and thus diminish the economic attractiveness of an area (Wallace, Drudy 1975).



Vicious circle of rural depopulation
(Wallace, Drudy 1975)

**The Highland Clearances entailed the eviction of a significant number of tenants in the Scottish Highlands and Islands. The clearances resulted from the improvement of agriculture, that drove the landowners to increasing the rent prices on their land, which in turn resulted in people all moving together in much overcrowded and unsustainable crofting communities. The collapse of these communities resulted in people having to move away from rural Scotland altogether.*

Region	Number of districts	1981 population ('000s)	Percentage population change 1961-71	1971-81	Difference
Scotland	24	998	–1.9	9.6	11.5
Wales	13	583	0.6	6.8	6.2
North	6	276	1.0	4.3	3.3
Yorkshire and Humberside	7	453	10.4	12.0	1.6
East Midlands	8	560	9.2	10.1	0.9
South West	20	1,368	10.3	11.0	0.7
West Midlands	8	427	7.7	8.1	0.4
East Anglia	12	1,035	14.5	12.9	–1.6
South East	4	357	21.1	12.1	–9.0
All rural districts	102	6,056	7.5	10.2	2.7
Great Britain	458	54,129	5.3	0.3	–5.0

Population change in rural local authorities, 1961-81, by region
The table shows a positive difference in population growth between 1961-1971 and 1971-1981 for rural districts, whereas this difference is negative for the whole of Great Britain, meaning that from 1971 until 1981 there was a larger urban-to-rural flow than the other way around.
(Champion, 1981b)

COUNTER-URBANISATION

Then, in the 1970s, this rural-to-urban movement was to a certain extent replaced by a urban-to-rural flow, as was first identified by Beale (1976,1977) and Berry (1978) in many countries one might classify as develop nations, including Great Britain. This trend was dubbed counter-urbanisation. Berry (1976) distinguished between two types of urban-to-rural flows. The first, which was given the name "extended suburbanisation", where people would move into, and slightly beyond, the suburbs at the expense of central city losses. This migration pattern is beyond the scope of this research, and will not be further discussed. The second flow would resulted in a steady repopulation of areas beyond the metropolitan daily system, which is known as counter-urbanisation (Berry 1976).

A result of the trend of counter-urbanisation can be found in Scoraig, Scotland. This is a small, remote town that saw its last resident leave in the 1960s. Then, in the early 1970s, a new group of people settled in the now abandoned town of Scoraig. At the time, newspapers described these newcomers as a "hippie commune" creating their own utopian vision of an off-grid life (Campsie, 2020). This interesting case study in remote living will be further analysed further on in this research.

One might conclude that at least part of this counter-urbanisation trend in Great Britain was related to the "hippie mentality" of the time. Subsequently, the magnitude of this trend has declined in the late 1980s and the 1990s. (Champion, 1987,1988; Champion et al., 1996). Especially when it comes to the in-migration patterns towards more remote areas, the trend of the 1970s and 1980s seemed to have slowed down significantly (Stockdale et al., 2000). In fact, for some of the more remote Scottish Highlands and Islands, it seemed as though this counter-urbanisation trend started to reverse from the late 1990s onwards. Especially the more remote and smaller Islands and Highlands communities have been facing hardships due to the reversing of the counter-urbanisation.

We can however identify several themes that remote or rural communities have in common who have been experiencing a continued population growth. Increased mobility, for example, has allowed people to commute more easily from a rural area to an urban environment (Cloke, 1985, p. 17). Unfortunately, for the more remote areas this is not a feasible solution. We might however be at the start of an evolution in how and where we work. At the time of writing the COVID-19 pandemic is forcing many people to work from home. The consequences of this pandemic might herald a situation where people can opt to work from home more often, allowing them to move further away from the urban centres than was previously possible.

A theme that seems to attract new permanent residents to more remote areas is by creating more labour-intensive work in for example the field of agriculture. Especially when the government would help stimulate this sector by subsidising labour intensive work rather than machined work, it could increase the urban-to-rural flow (Cloke, 1985, p. 20). A current trend that might actually act as a catalyst for people wanting to move to remote rural areas is the surge towards alternative rural life-styles based on self-sufficiency and voluntary simplicity.

Photo © Ed Gold
The off-grid, self-sufficient community of Scoraig, Scotland. Relying on a sustainable model of water and electricity production.

LIVING OFF-GRID

To be able to determine how new people can be attracted to more remote areas so that they can be repopulated, it is important to understand why people might move away to such isolated places. One of the more important reasons for people to do so, is their desire to get away from the hustle and bustle of daily life in the city. People who do so are looking for a simpler life, and often have a desire to live a more sustainable life as well.

Another reason people might have to move to more rural areas is the increasing ability by individuals to fulfil their residential preferences (Bolton and Chalkley, 1990). Previous research examining the motivation for migration have noted a desire for a rural lifestyle with many migrants viewing the rural environment as safe and pleasant. An important distinction is made between 'anti-urban' motivations emphasising, for example, regional differences in house prices (Owen and Green, 1992) and `pro-rural' motivations which focus on the immediate residential environment of the migrant (Halliday and Coombes, 1995).

Beyond what their reasons for relocating to remote communities might be, it is important to note that the people who do so have a willingness and an economic flexibility to do without many of the 'necessities' of urban life (De Jong and Sell, 1977; Long and De Are, 1982). There is thus a situation, in some rural areas, whereby ruralities are apparently out-migrating in search of urban service standards while urbanities are in-migrating with a 'back to the land' acceptance of rudimentary rural-standard facilities. It is therefore important that this 'back-to-basics' mentality is also reflected in the lifestyle that these people hope to find. However, it is shown that children of the people that move to rural communities are more likely to leave when starting their adult life when the amenities and facilities are sparse. A balance therefore needs to be found between the luxuries of urban and the simplicity of rural life.

REMOTE LIVING COMMUNITIES

Renewable energy sources can be unreliable, but offer a great starting point for off-grid communities that want to be self-sufficient.
(Fitzgerald & Dearborn, 2017)

SELF-SUFFICIENT LIVING

All around the world there are people or even whole communities living off-grid. This means that they must be at least partly self-sufficient and that they must thus (partly) produce their own electricity, water and food. Many case studies can be observed, and with the enormous technological advancement of today, the options in a self-sufficient existence are limitless.

One of the most difficult things to provide for oneself, is food. Besides having the proper infrastructure and systems in place to do so, it also takes some amount of work on a daily basis.

The provision of water can be done in various ways. There is always the option of hauling water in bulk. However, the downsides to this are evident, especially when one lives remotely. Another option is to use water from a natural source, such as a river, a lake or a spring, where the condition applies that either of those needs to be present in close proximity to where it is needed. Another option is to create a well, which is by far the most popular choice for off-grid water. The downside to it is that it is relatively expensive to dig a hole that is deep enough (Davidson, 2021). Another option is to catch rainwater and store it. The challenge here is that enough surface area is needed to catch the water, and additionally, a way to pump the water from the storage to the tap is needed.

On average, a person in the UK uses 150L of water a day (Water UK, 2020).If this amount of water is to be provided by catching rainwater, an minimum amount of horizontal surface is needed where the water is caught. In the driest month, which is usually July, it still rains at least 30mm in the UK (Statista, 2021). This means that a horizontal surface of 150 square metres provides enough water per day for one person. Of course, it might not rain for various days so the water needs to be stored to be able to bridge at least a seven day period, amounting to a storage of about a thousand litres per person. On average, however, it rains about 90mm a month, which means that usually a surface of 50 square metres suffices to produce water for one person.

In terms of electricity, the options of nowadays are plentiful. When looking at the case study of Scoraig on the next page for example, it becomes clear that it is even very well possible to create a fully sustainable network for electricity that is fully off-grid. The problem with many of the sustainable energy sources, is that they can be unpredictable. The sun doesn't always shine, and the wind doesn't always blow. To counter such issues, it is often wise to make use of multiple renewable sources to generate electricity. Additionally, the electricity should be stored, so none of it goes to waste, and even on a rainy day without wind access to electricity can be granted.

REMOTE LIVING

REMOTE COMMUNITIES ON THE SCOTTISH ISLES

Photo © Ed Gold

SCORAIG, A CASE STUDY

On a peninsula in the North Western Highlands of mainland Scotland a small off-grid community can be found. The only way to access the small town of around 80 residents is by a five mile hike, or by boat (The Newsroom, 2017). The town is not so much remote, as it is inaccessible. They remain self-sufficient by harvesting solar and wind energy, having their own cattle, and growing their own produce (BBC, 2017).

Most of the residents have modern electric amenities, such as washing machines and tv's, thanks to a man named Hugh Piggott, who moved to Scoraig in 1975 (BBC, 2017). Hugh had a background in physics, and was one of the early adopters of wind turbines. He was the person that made Scoraig the first Scottish off-grid community to function fully on renewable energy.

The people of Scoraig do not have cars, as there are no roads in their town, or even in the proximity of town. On the peninsula they use quad bikes to move around, while the boat is their main means of connecting to the outside world. Almost all residents have a boat of their own, and additionally, they have one communal boat that is accessible to anyone.

For the education of the younger generation they are dependant on a primary school in town. When the children reach the age to go to middle school, they stay in a hotel during the week in another town, as there is no middle school in Scoraig.

In 2017 photographer Ed Gold went to live among the residents of Scoraig to capture the essence of the community. He talked with many of the residents to hear their stories about their experiences and also about the reasons they have for living off-grid (BBC, 2017).

One of the themes that recurred in these talks with the residents, was the hardships they faced in terms of weather. Many of the activities that the people of Scoraig engaged in are outdoors activities. On top of that, the houses they live in are often very much exposed to the elements. This makes living off-grid in Scotland quite difficult for some people, as strong winds and a lot of rain are a given (BBC, 2017). On the other hand, some of the residents see it as a positive thing to be so intimately connected with nature.

What makes this tight-knit community work so well according to the residents is the fact that they engage in many group activities that strengthen their bond and their sense of community, while also looking out for each other. Everyone knows one another, and everyone trusts one another (BBC, 2017).

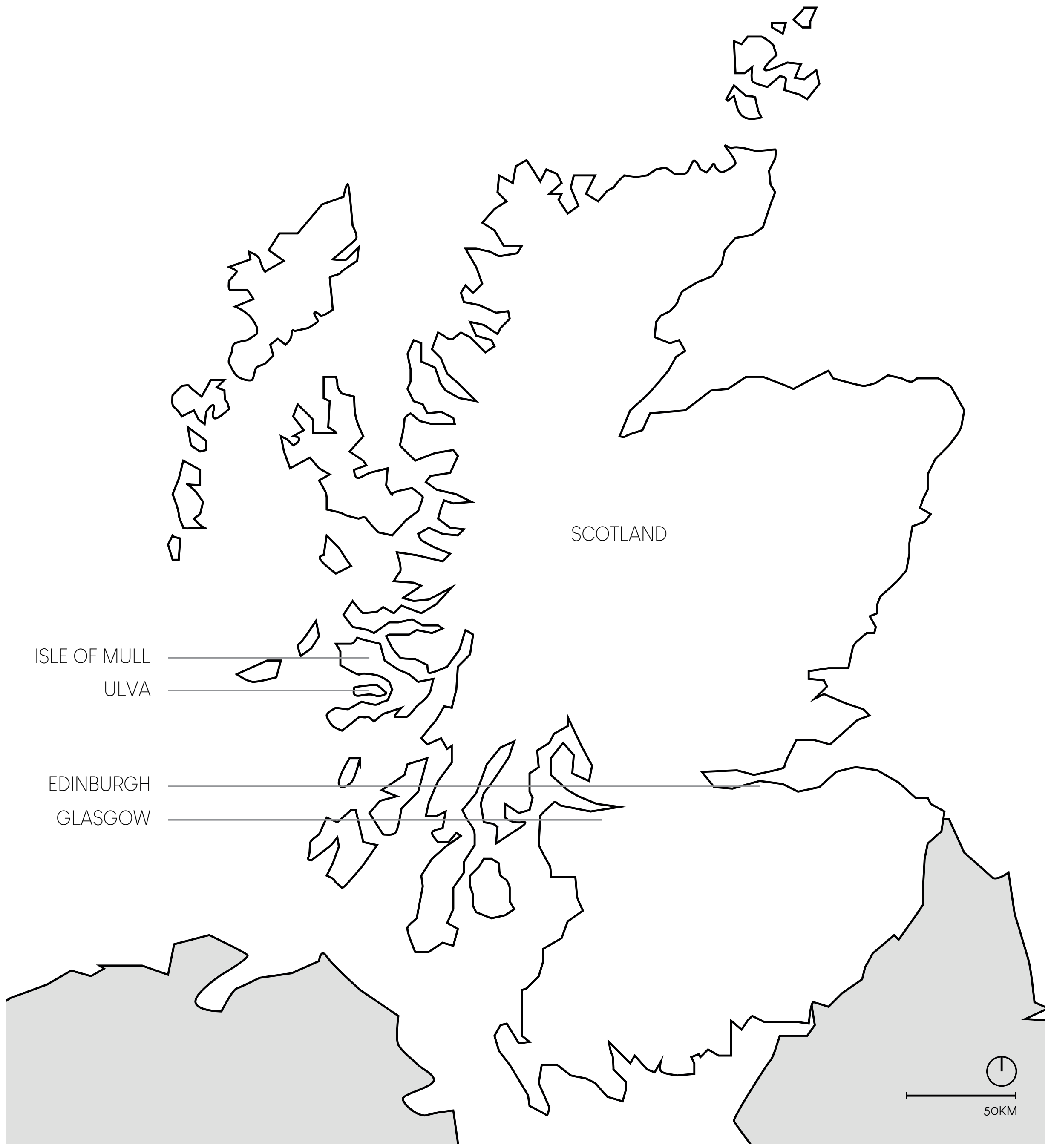
Dealing with an ageing population is one of the challenges that Scoraig is facing. It is mostly older couples that move towards the town, while younger people are more likely to leave once they go to college.

REMOTE LIVING
COMMUNITY OWNED ULVA

Photo © Rebecca Munro, courtesy CBC Radio
A sign in front of the Ulva ferry, on the isle of Mull, Scotland.
Image retrieved from: https://www.cbc.ca/radio/asithappens/as-it-happens-friday-edition-1.5130836/scottish-isle-of-ulva-population-5-makes-pitch-to-grow-community-1.5124744

INTRODUCTION

The island of Ulva, which is located in the South-West of Scotland next to the Isle of Mull, is the first of the Scottish Isles to launch initiatives to combat the declining population. In 2018 the island was bought by the remaining five inhabitants with financial aid from the government. They are now the communal owners of the Isle of Ulva. Their goal is to launch various initiatives to attract new permanent residents to the island. They have started by introducing cattle to the island, as well as by transforming some of the land to grow crops on, and by renovating some of the outdated buildings on the island.



A map of Scotland with the fringes of England and Northern Ireland. The island of Ulva is located in the 'island belt' of Scotland, Ulva is encapsulated for the most part by the isle of Mull.

LOCATION

Scotland can be subdivided into three categories when it comes to its lands. There is the mainland of Scotland, where its main cities Glasgow and Edinburgh are located. Then there are the inner Hebrides, which are the islands just of the West coast of Scotland. Lastly, there are the outer Hebrides, which are the islands on the fringes of Scotland.

Ulva is part of the inner Hebrides, together with the island of Mull, that basically encapsulates the island of Ulva.

It's about a five hour drive from either of the major cities of Scotland to the island of Ulva. A ferry needs to be taken to Mull first, after which another ferry can be taken to go the Ulva.

REMOTE LIVING
COMMUNITY OWNED ULVA

A map of Ulva with the fringes of Mull partly visible. The only way to reach Ulva is by ferry from Mull. The crossing takes just five minutes, as the body of water is only 200 metres wide at that point.

LOCATION

The island of Ulva is about 12 kilometres in length, though most of the island is uninhabited. The centre of gravity for the population of Ulva is in the East, where the ferry landing is located. There is one unsealed road that leads from the inhabited East to the West of the island, though it is mainly used to get to the island of Gometra, which is even more remote than Ulva. The connection there is by a small bridge that allows for small vehicles to cross.

None of the roads on Ulva are sealed, so cars are not present on the island. The residents more around on smaller motorised vehicles, such as quad bikes and cross bikes.

The ferry from Mull to Ulva goes about once an hour during working hours from Monday to Friday. Though most residents on Ulva have their own modes of transportation that provides passage to Mull.

LOCATION

A map of the inhabited part of Ulva. The East side of the island is green and lush, while the middle and west part of the island are more barren.

The area on Ulva around the ferry crossing is the most populous part of the island. Though the population is down to just six, there are many more empty houses and buildings on the East coast of Ulva.

A primary school for the younger residents of Ulva is situated on Mull, right next to the ferry. Unfortunately, a good secondary school is lacking in the close proximity to Ulva, which means that secondary schoolers stay in a hotel close to their school during weekdays and come home in the weekends.

Most of the Eastern coast of Ulva is relatively green and lush, due to it being protected from heavy weather by the enclosing island of Mull in the East, and the protection from the 350 metre high peak on the West of Ulva. Some of the land in the East is therefore also suitable for irrigation and keeping cattle.

Ulva Ferry, painter unknown
Image retrieved from: https://www.isle-of-mull.net/locations/islands-around-mull/ulva/

HISTORY OF ULVA

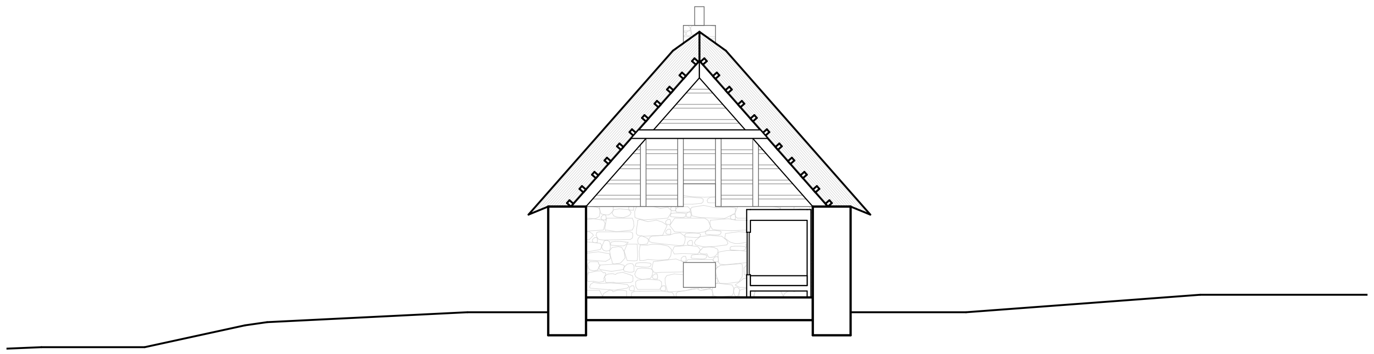
Much of the island of Ulva is formed from Cenozoic basalt rocks, which are formed into columns in some places on the Island. Ulva has been populated since the Mesolithic. Traces of these former residents have been found tracing back as far as 12,000 years ago. Around the early middle ages, Ulva was under Norse occupation. The name Ulva can be traced back to this period, as the name seems to be a derivative of Ulvoy, meaning 'wolf island' (Explore Isle of Mull, z.d.).

After the Norse period, when Ulva became part of modern day Scotland, Gaelic became the dominant language. At its peak, Ulva boasted a population of over 800. Among them was explorer David Livingston, and the founder of modern day Australia General Lachlan McQuarrie (Andoran House, 2016). The last of which was burried in a mausoleum on the Isle of Mull, with a view over Ulva.

Unfortunately, the number of residents was drastically decreased during the Clearances. The Highland Clearances took place during 1750 and 1860, and in this time a significant number of tenants in the Scottish Highlands and islands were evicted. The people that remained on the island were mostly farmers. In fact, Ulva used to export potatoes throughout the 19th century rather succesfully (Keay, 1994).

After the Clearances, the population of Ulva continued to decline, until it reached its all-time low in 2019 with just five residents being left.

Then, on 21st of June 2018, the island residents became the communal owners of the island, hoping to turn the tide around and turn the island of Ulva into a populous thriving community. Initially, when the island came up for sale, many investors and rich people from Russia and the Middle East were interested in buying, as to turn the island into a resort, or a personal retreat. Luckily, Scottish Land Fund pledged £4.4 million towards a community buyout of the island (Drysdale, 2018), and the North West Mull Community Woodland Company took ownership of the island.



Sheila's cottage section 1:100

Sheila's Cottage.
A restored traditional thatched cottage on the East coast of Ulva. It now serves as a small visitor centre and museum that tells about the rich history of the isle of Ulva.

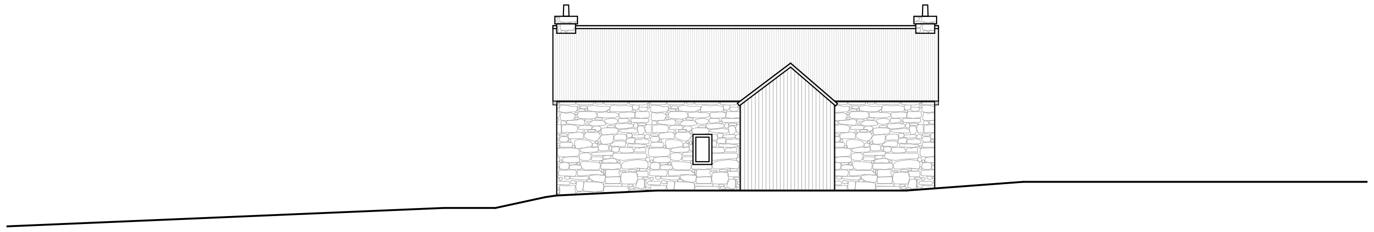
SHEILA'S COTTAGE

This reconstructed thatched cottage was last lived in by Sheila MacFadyen. She lived in it until around 1950, when she became too old to be living off-grid with as few amenities as were present on Ulva at the time. The cottage is located right next to the landing point for the ferry, and forms together with the boat house and few other cottages the ensemble that one sees when arriving on Ulva (Undiscovered Scotland, z.d.). Most of the traditional, older houses on Ulva resemble this housing concept.

The cottage consisted of two rooms. One where Sheila lived, with space for a modest kitchen and bed, grouped around the fire place. And one room where the livestock would be kept. The cottage has now been restored and repurposed to become a visitor centre and museum that showcases the history, present and future of the island of Ulva to tourists. The room where Sheila lived has been recreated, while the former space for the livestock has been turned into the museum part of the centre (Undiscovered Scotland, z.d.).

The cottage is constructed using a simple A-frame timber structure on top of a heavy stone wall. The roof is closed with straw thatch. The thatched roof is a reasonable insulator, but the stone wall not so much. That's why all furniture is grouped close together around the hearth. Additionally, the bed is situated inside a timber cabinet, which provides an extra layer of insulation at night, similar to the box-in-box principle in terms of insulation.

TRADITIONAL STONE HOUSE



Ulva stone house elevation 1:200

Photo © Alamy Stock Photo

This traditional house on Ulva is basically a modernised or updated version of Sheila's cottage. The thatched roof has been replaced by corrugated sheets, but the principle is almost identical. To this house an extension has been added, which acts as the entrance hall of it.

What can be clearly observed in this picture is the way this house blends with the landscape. It becomes clear that the stone that is used to construct the façade is locally sourced. The heaviness of the walls grounds it in its surroundings, while the grey of the corrugated sheets mimics the sky and the ocean. The patina on the sheets was maybe not planned, but offers a nice contrasting voice in the otherwise nature-blended colour palette.

The fact that the house is constructed with stone, offers a clear disadvantage in terms of façade openings. The span one can make using stacked stone is very limited, which results in relatively narrow windows. This is unfortunate, as the beautiful panoramic view would be best observed with more horizontal windows. Then again, the people here would spend most of their time outside their homes, offering them the most panoramic views of all.

Photo © Undiscovered Scotland
Image retrieved from: https://www.undiscoveredscotland.co.uk/ulva/ulvachurch/index.html

ULVA CHURCH

The church of Ulva is located about one kilometre from the ferry landing, in the Northeast of the island. It follows a standard T-plan design that was drawn by Thomas Telford (Undiscovered Scotland, z.d.-b). It was constructed in 1828, when Ulva was still boasting a population of over 500 inhabitants. At the time, the church could accommodate most of them at the same time.

When in 1845 the new laird took ownership of the island and starting clearing out most of the population to allow livestock to graze, the church became a much too large space for the few residents left. Then, in the 1950s the owner of Ulva at the time converted the church into a multipurpose building. It now also serve as a community centre, where the incredibly reduced community could gather for various purposes.

However, a building of that size and age needs proper maintenance, which is hardly feasible for a population that is down to just six people in 2020.

RUINS

Around the island, many ruins such as the one on the picture can be found. A sad trace of the clearances in the 1850s. These cottages were all presumably constructed in a similar fashion as the restored Sheila's cottage.

Photo © Michelle Eldershaw
Due to the enormous population decrease over the last centuries, many ruins of former houses can be found on the island.

THE PROPOSAL

"There is a saying that if anything mechanical stops working on Mull, it will end up on Ulva."

(Andoran House, 2016)

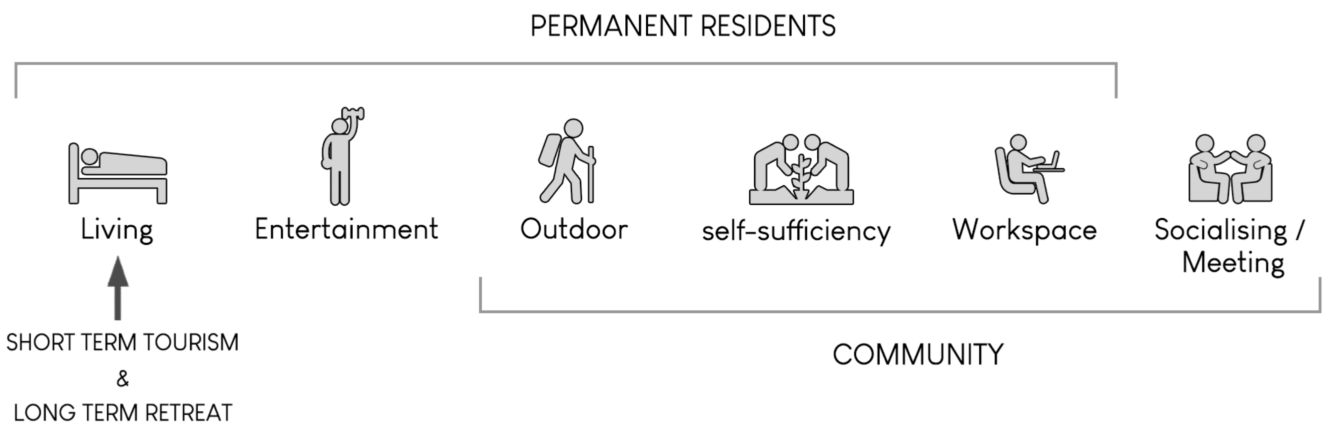
INTRODUCTION

It seems as though Ulva has not been in control of its own fate for a very long time. This changed back in 2018 when the small population became the collective owners of Ulva. Since then, a small museum was erected in a newly restored traditional thatched cottage, a cattle was introduced to the open fields of Ulva, and various other buildings are being restored and repurposed to attract new residents.

What the people of Ulva are missing as of now is a way of dealing with the co-managing of the island once the population starts growing. They will need communal facilities that will help with the management, as well as with the establishing of a strong and tight-knit community that can continue growing for decades to come. They will needs a space to come together, to work, to socialise that is accessible for all of the community.

Therefore, a new building will be introduced to the island. One where multiple small households will live together using a co-living concept. The concept of co-living will help establish a community feeling, which will in turn make the residents more engaged with the rest of the island community. These residents will manage and maintain a small estate that is self-sufficient in its own right, while accommodating in space for the community of the island at large, for various functions.

In the foreseeable future, the residents of Ulva want to grow the population to about 20 people. These people should all be able to meet and socialise in this new building. On top of that, the current owners of Ulva are betting big on tourism as one of the main ways of generating income. The newly proposed buildings will provide opportunities to exploit this bussiness. And lastly, the community is hoping to become self-sufficient to a large extent, by growing their own crops and managing cattle on the island. This concept of self-sufficiency will become an important feature of the new building as well.



Schematic of the programme, with the involved actors.

A SPACE FOR ALL OF ULVA

One of the more difficult aspects of the programme of the building, is the duality of having a very communal programme on the one hand, while also wanting to create private spaces for the collective owners of the house.

It is important for the building to provide all necessary means to the residents to generate income and provide in their every day needs in a sustainable and self-sufficient manner. On top of that, the Ulva community needs their space in the building as well.

It is important to also take into account how the building might be used around the year. In Scotland, winters can become rather harsh due to the strong winds and rainfall. This means that the communal functions of the house will be less intensively used during these colder months, as people prefer to stay indoors. This holds true for the residents of the house as well. During these months, they will be spending much more time inside the house itself, which means that the house should provide enough ways to entertain the occupants, and provide ways of keeping physically fit.

To provide the residents with the means to remain self-sufficient to a large extent, they will need a fruit and vegetable garden, along with the irrigable land on the East of the island. They will also need plenty of storage for the winter months, when few vegatables can still be grown.

An important part of work-culture nowadays is flexible office space. More people work from home, or have bussinesses that can be managed over the internet. Workspaces that accommodate in those needs should be provided with the house, and should be accessible to both the residents and the community.

REMOTE LIVING
LOCATION

INTRODUCTION TO THE SITE

Just South of the more inhabited part of Ulva, spectecular basalt column cliffs can be found. These cliffs are a real tourist attraction, and are relatively easy to reach from the ferry landing. The land here is more barren due to it being closer to the open ocean, and being more susceptible to the strong Southern winds that Scotland is known for.

Here, one truly feels separate from the rest of the world. Especially in winter time, when the land is even more barren, the peaks of the distant mountains are covered in snow and the location is no longer very accessible due to the somewhat hostile weather conditions.

It might just be the perfect location to build a house that truly embraces remote living with all its challenges and its perks. A place that the whole island community may enjoy and be proud of, and a place where tourists might be introduced to the charms of living in- and being part of a remote community.

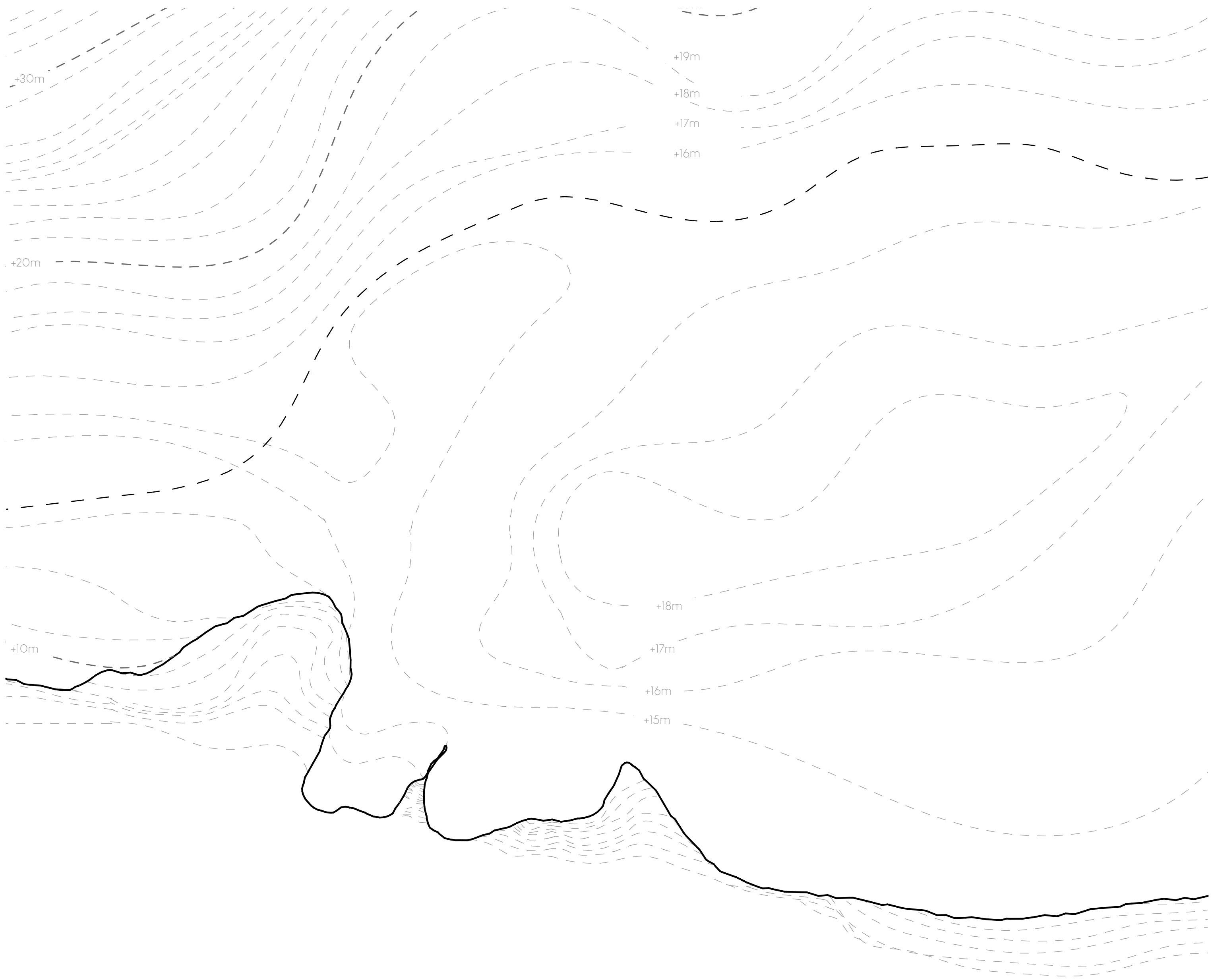
A map of the inhabited part of Ulva. The East side of the island is green and lush, while the middle and west part of the island are more barren.

SITE ANALYSIS

The location for the proposed Big House is about 800 metres removed from the ferry landing. An unsealed path leads along the location, to accommodate, among others, the tourists that want to take a picture of the basalt cliffs.

The land here is hardly suitable for irrigation, but when the right conditions are created by the proposed building, the house can enjoy its own vegetable garden so it can produce part of its food. Because of the close proximity to the open ocean, it also offers the opportunity to catch sea food to provide to the residents and others on the island. On top of that, the existing oyster farm can very easily be managed from the new building.

A challenge that the location faces are the steep cliffs that hardly offer any easy ways to reach the water. Another challenge that presents itself is that the island of Ulva is mostly disconnected from the main net, which means that especially the new building in this location needs to provide for itself in terms of water and electricity. Also the strong Southern winds have more effect here, as the location is not protected by the relief of the island like the area around the ferry. Instead, the site faces the open ocean, and thus a way should be found to offer some protection from these climatal influences.



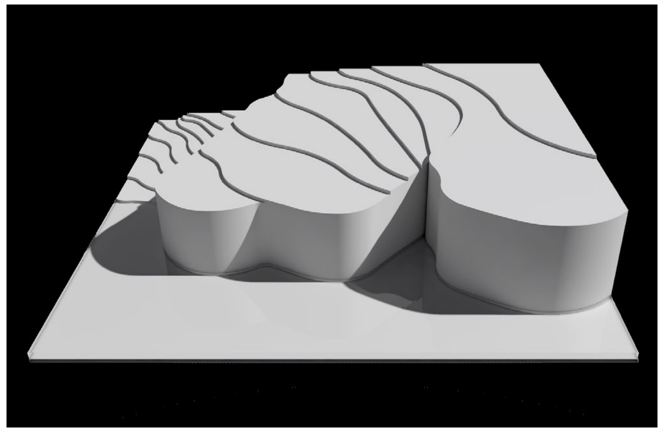
Site plan of the area around the cliffs.
1:2000

SITE PLAN

On the Southern coast along the cliff edges of Ulva, two cliff plateaus really stand out. The two plateaus are bordered by an inlet on both sides, and are separated from one another by a crack. The left plateau slopes down somewhat, and is found on an elevation of about 12 metres, while the other plateau sticks out above it on an elevation of 14 metres.

The left platform is often photgraphed from the Western end, of which a picture can be seen on page 204 and 205. To get to this location, an unsealed path leads along the more flat terrain of the site. The path starts in the East close to the ferry landing, and it ends all the way in the West of Ulva, where the bridge to Gometra is located.

North of the path, the terrain quickly starts to slope upwards, ascending all the way up to the Ulva peak of 350 metres.



3D site model of the cliffs.

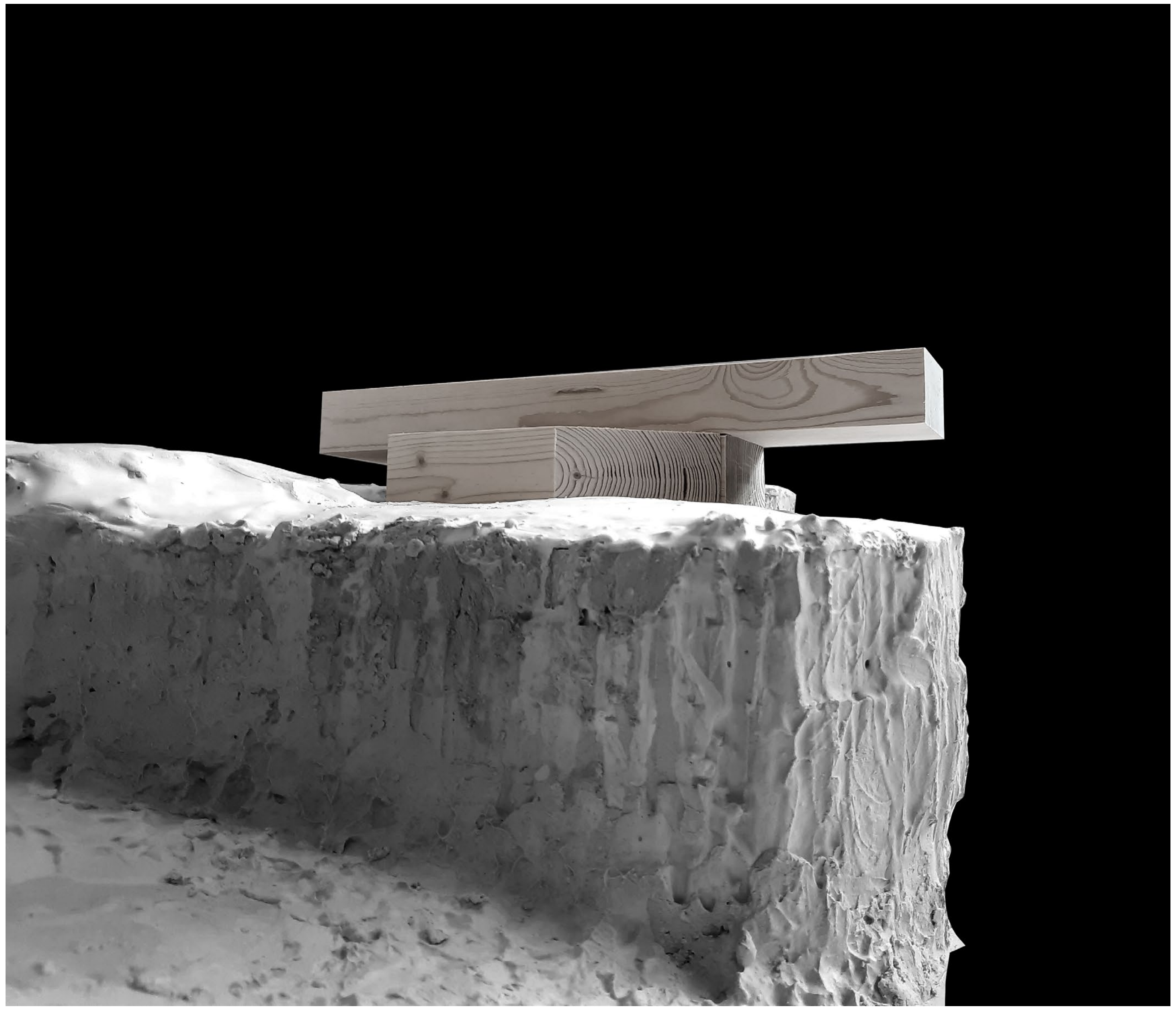
A mood board inspired by local textures and materials to be found on Ulva.

LOCAL MATERIALS AND TEXTURES

The chosen location on Ulva is more barren than the more inhabited Eastern part of the island, as has previously been discussed. The land around the site is dominated by the basalt column cliffs, and other basalt stone that stick out of the ground. Most of the basalt stone on Ulva, especially further from the shore, have a reddish tint to it. This might be due to a high concentration of iron. The cliffs on the coast show less evidence of this, which could be due to the higher levels of erosion.

Most of the rock ground has been covered by a layer of clay, with low levels of vegetation on top. Around the cliffs' edge, exposed to the Southern winds, the vegetation remains low and is limited to grass and small shrubbery.

The sea plays an important role in the colours and textures as they are experienced on the location itself. When looking a little further, the buildings seem to consist of dry stacked stone walls, with either corrugated metal sheets as roofing, or thatched roofs. Another important building material, although it is less seen in the exteriors of the buildings due to erosion, is timber. Neighbouring island Mull boasts a pine wood plantation.

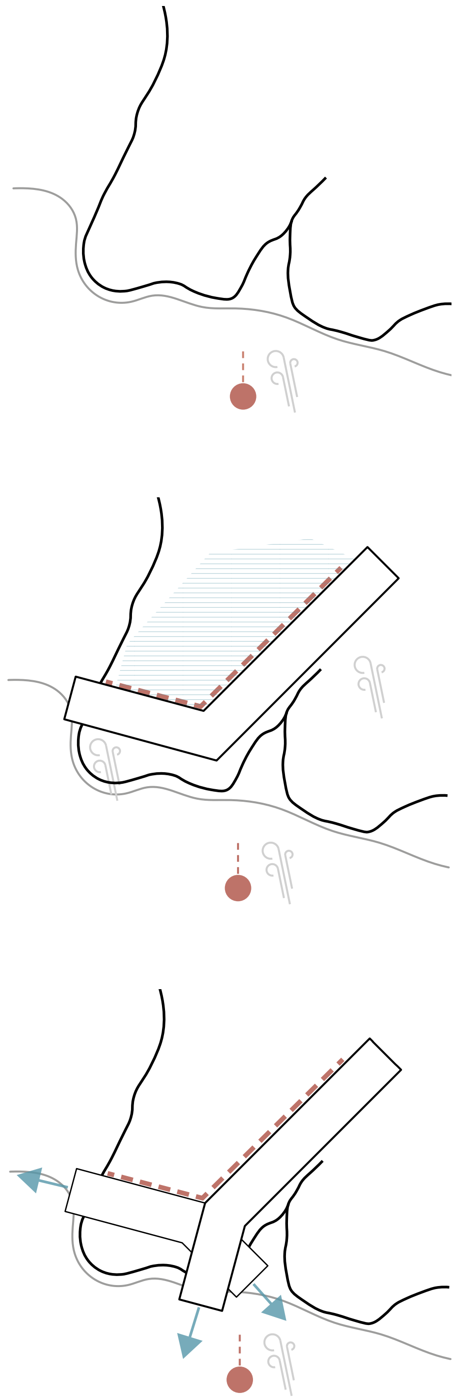


An extensive site model was created to help understand the location.

SITE MODEL

To get a more thorough understanding of the location, an extensive and large model of the site has been produced. The model maps out an area of about 100 metres by a 100 metres in a scale of 1:100. Few thorough and precise maps of the location exist, so the making of a model was a crucial step in getting an understanding of the features of the site. The site model is made using gypsum, to mimic the stone-like textures that dominate the location.

The model was extensively used to determine shapes and materials that would compliment the location, while also offering enough counterbalance to the drama of the cliffs themselves. The image on the left shows one of the very first ideas for the location. The shape is very horizontally oriented to contrast the vertical basalt columns that give the cliff its dramatic expression. The large overhang offers a dramatic experience that compliments the location. The base of the shape, on the other hand, is solidly embedded in the face of the ground.



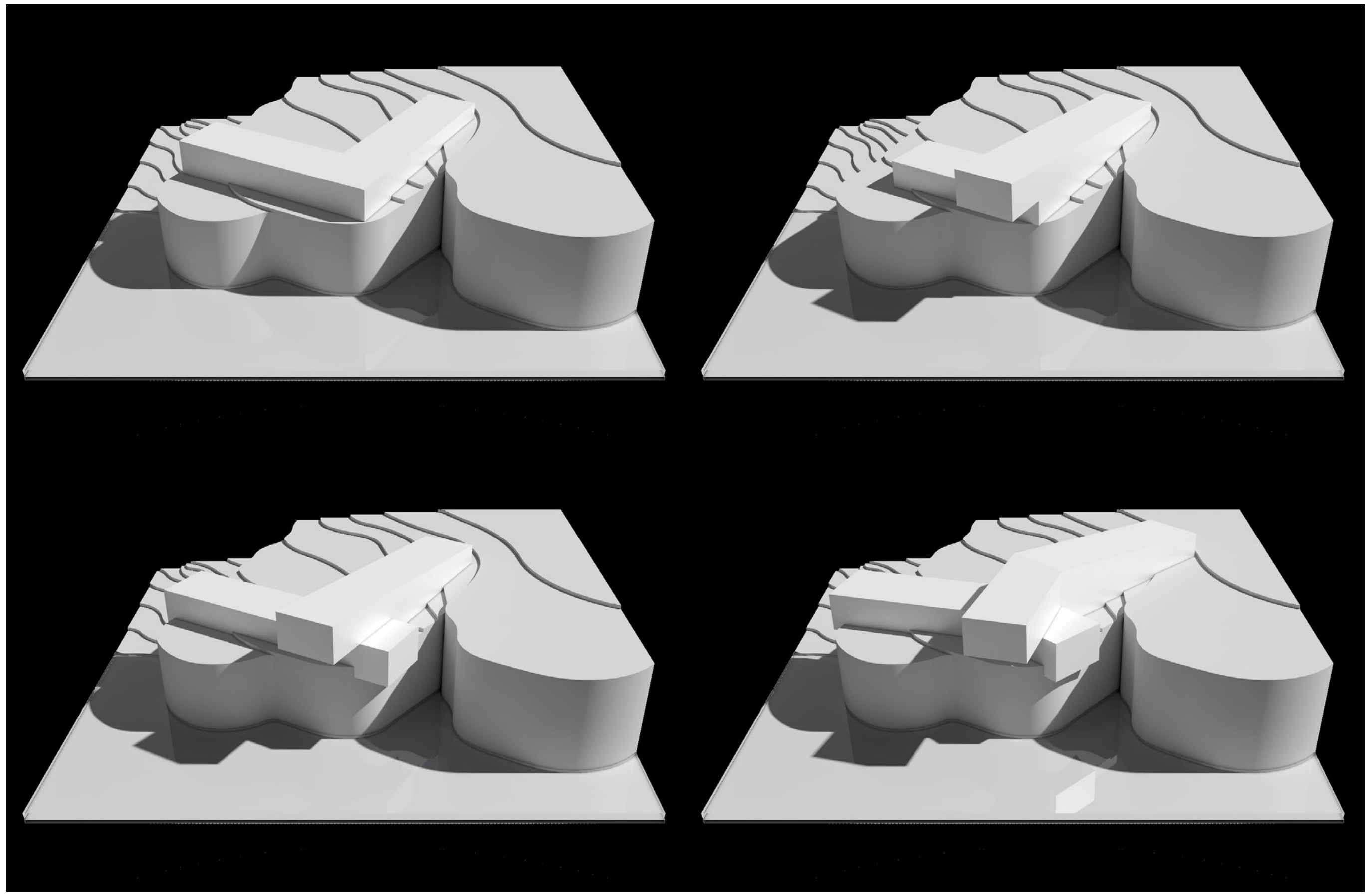
Dealing with the harsh climatic influences in a way that creates a protective oasis, while still making optimal use of the views.

DEALING WITH THE HARSH CLIMATE

One of the main challenges that this location offers, is its climate. The impact of the Southern winds has already been discussed, and it leaves all vegetation to remain rather barren. The challenge is to create a safe haven, or an oasis where vegetable gardens can be erected, and where people can comfortably live, both inside and outside.

This creates somewhat of a duality in the programme of the building. On the one hand, it needs to be protective from the South, while it is more open towards its protected centre on the North. On the other hand, it needs to work with the beautiful views in the South, the East and the West while it also fends the occupants from the weather on this side.

One of the very first instincts was to create a sort of V-shape, or a wedge, that directs its point towards the South Southeast, where the winds mostly come from. This results in the conceptualised protected oasis in the middle of the wedge.



Form study on location.

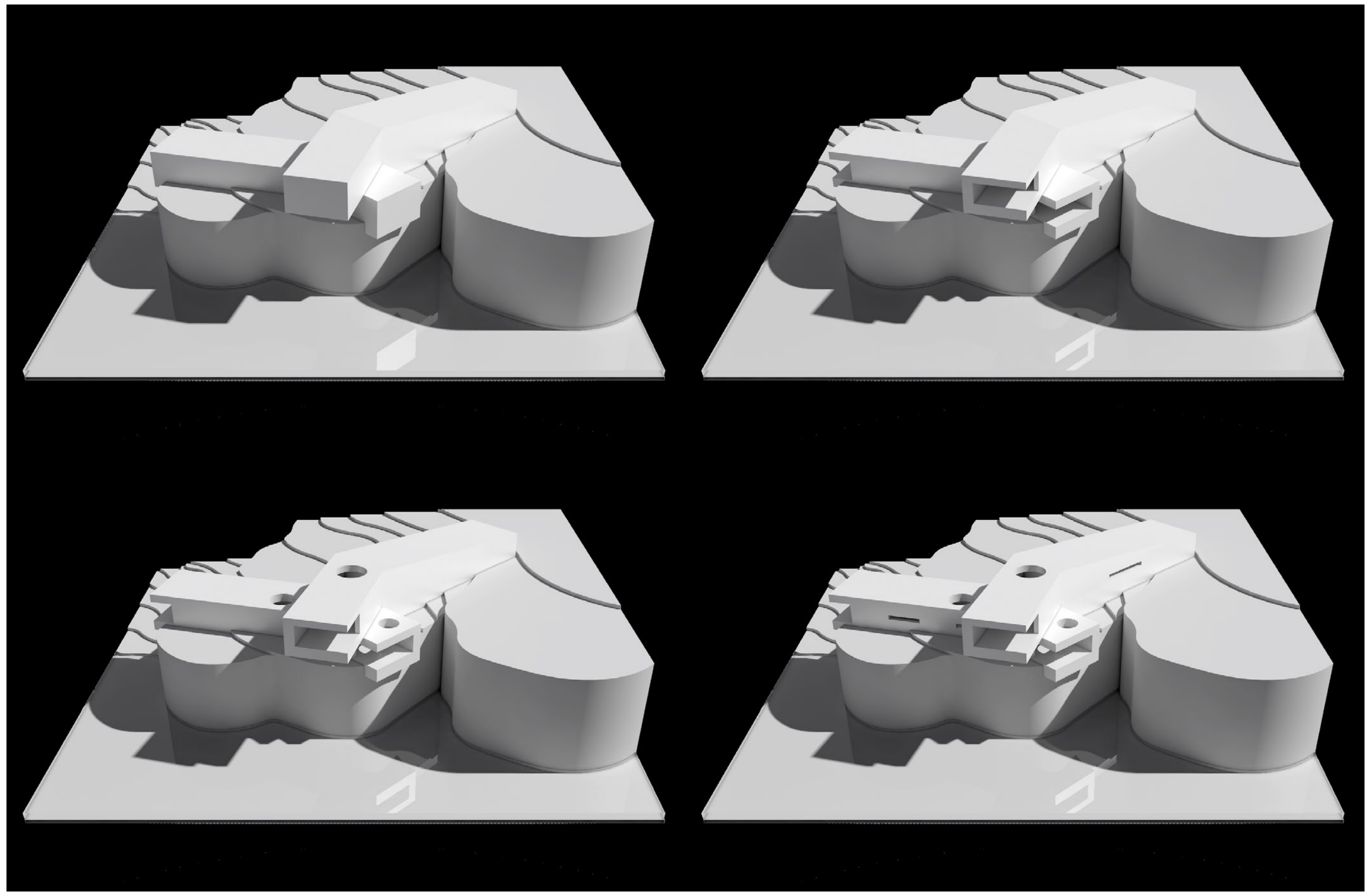
FORM STUDY

Once the main shape had been determined to be a wedge, various options have been experimented with. The most important consideration here was to not just create this oasis in the centre, but also have the shape of the building work with the location and the views around it.

(1) The V-shape itself hardly interacts with the cliff and its surroundings. Instead, it seems somewhat out op place. (2) The idea then became to have a volume lift up from the ground, and rise over the cliff to create a dramatic play between the building and the cliff. This overhanging volume would seem to ascend from the ground by its sloping roof in a response to the downwards sloping terrain. This creates both a dialog between the building and the ciff, and between the building and the surrounding views. Yet, the cliff plateau East of the building seems to remain out of the equation when it comes to how the building deals with its context.

(3) In the third form study, the building is exploring all directions around the cliffs, by creating two beams that are laying on top of one another. This results in a cross with its largest wedge on the Northern direction, where the protected centre is. The building maintains its dramatic interplay with the cliff by creating overhangs in all directions. The shape, however, feels somewhat forced into place. The directionality of the beams seems arbitrary, and hardly in harmony with the views around it.

(4) In the fourth form study this last challenge is combatted. The wedge is made wider, accommodating more to the residents to create the oasis. Where the two beams meet, they change directions, as from that point on aiming towards the view is the main directive, This results in two kinked beams which respond to both their direct environment, as well as their more distant enivornment by adressing both the drama of the cliff, as the comforts of its residents.



Formgiving of the openings in the solid volume.

FORM STUDY

(1) During the establishing of the basic shape of the building, it had become apparant that the site was asking for a heavy, massive building that would offer countervailing power to the strong dramatic appearance of the cliffs. On the same time, an important quality of the building would be to create a safe space for its occupants in such a harsh environment.

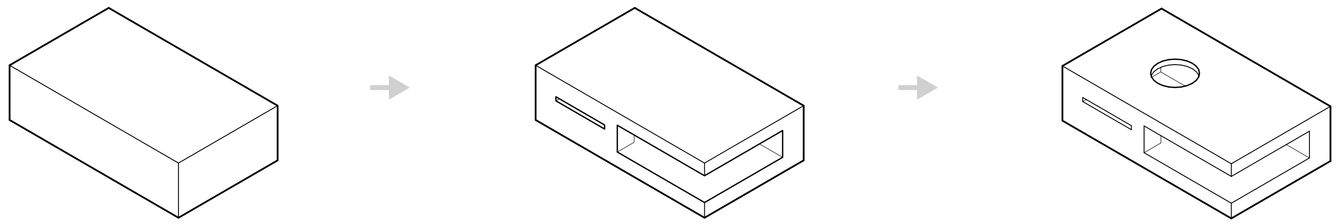
A big challenge that arrises is a programme that requires a building that exerts its massiveness, is the openings that provide light and a view of the surroundings. It's extremely important that the openings emphasise the heaviness of the building, without compromising in letting light in.

In sea-side architecture, the view is one of the most important qualities that are being taken into account in the design. Often, a horizontal panoramic way of framing the view is implemented in façade openings.

(2) For this building, the choice was made to cut away a corner opening in each of the ends of the two beams that form the basic shape of the building. This results in an extremely wide-angle view that captures the surroundings. The opening height itself is kept somewhat smaller, to give the impression of extremely thick and heavy floor and roof slabs. This way, the massiveness of the building is maintained. On the same time, this means that the interior space is higher than the windows, so it is important to get additional light inside.

(3) The choice is made to introduce circular skylights, that help soften the space, partly due to the soft shadows it creates.

(4) Then, in the spaces that are not in the ends of the two beams, very wide and low windows are introduced. They frame the view exactly from certain positions. These measures create a strong concept for the openings in the building volume, while strengthening the massive character, without compromising on light or view.



Sculpting out the openings of a solid volume.

Material palette in response to the location.

RESPONSE TO LOCAL TEXTURE PALETTE

As the basalt column cliffs have a strong, heavy, and very vertical character, the choice was made to offer a countervailing power towards this verticallity by introducing horizontally oriented beams as the main shape of the building. To emphasise that horizontal character, the material was to express a similar directional aesthetic. The choice almost immediately fell on concrete as a building material, to express the heaviness of the building.

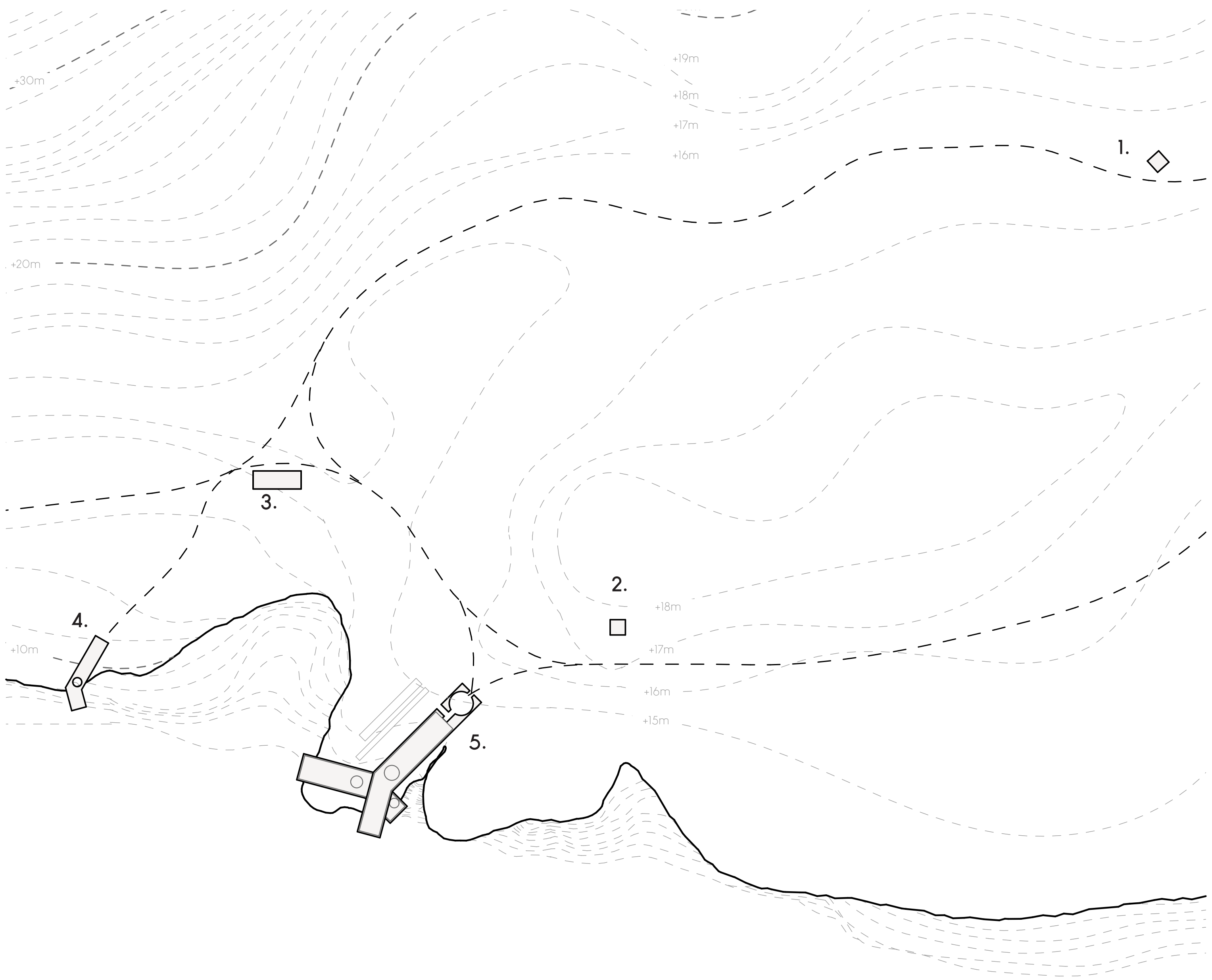
To that end, rammed concrete seemed to be the perfect fit in this location. Some of the major problems with the location of this building is the accessibility. Rammed concrete offers part of the solution, since not all concrete has to be poured in one go. Instead, every other day a truck can go on site and deposit a load of cement. The mixture for rammed concrete consists of minerals and clay from the soil, mixed with the cement and a small amount of water. The local soil can be used to gather the materials for the mixture. Creating a building out of rammed concrete is a rather labour intensive job, which could help stimulate the local economy. It requires timber formwork, for which locally sourced wood can be used. It also requires the ramming of the mixture, which could prove a great way for the residents of Ulva to work together on creating their own communal Big House.

The soil of Ulva has a relatively high iron containment, which colours the clay and earth slightly red. This will also be visible in the rammed concrete. Another material that can patly be locally sourced is the concrete wall plaster. Local additives such as clay can be added to give it a colour to mimick the soil and rocks on Ulva. This plaster will be applied in horizontal stripes to again counterbalance the verticallity of the cliffs.

Locally sourced timber will be used for some of the interior finishes to help soften the spaces. It works especially well in views where the focus is the more horizontal horizon, which will be emphasised by framing it around vertical timber slats.

Metal elements will be introduced to create a more interesting interplay between the light and the surfaces of the project, as metal has reflective properties that few other implemented materials possess.

REMOTE LIVING
PROPOSAL OF THE ENSEMBLE



Site plan with the implementation of the architectural ensemble of newly introduced buildings
1:2000

SITE PLAN

To make optimal use of the location, an ensemble of buildings is created that work together to create a self-sufficient and self-sustaining environment that offers the residents every possibility in providing for all their needs.

1. THE WATCH TOWER
The very first building along the way from the Ulva ferry to the new buildings is the watch tower. It is a vertically oriented sober building that can be climbed. It offers a first view towards the ensemble that is created on the location. Also, due the fact that weather conditions in Scotland can change rather rapidly, this building offers a shelter on the half-way mark between the Big House and the last built structure on the inhabited side of Ulva.

2. THE POWER HOUSE
The second building is another watch tower. This one, however, is located on the other road that leads directly to the Big House. This building is located on a slightly higher elevation, and faces directly to the sea. It has a small vertical-axis windmill on its top, and produces part of the electricity for the ensemble of buildings.

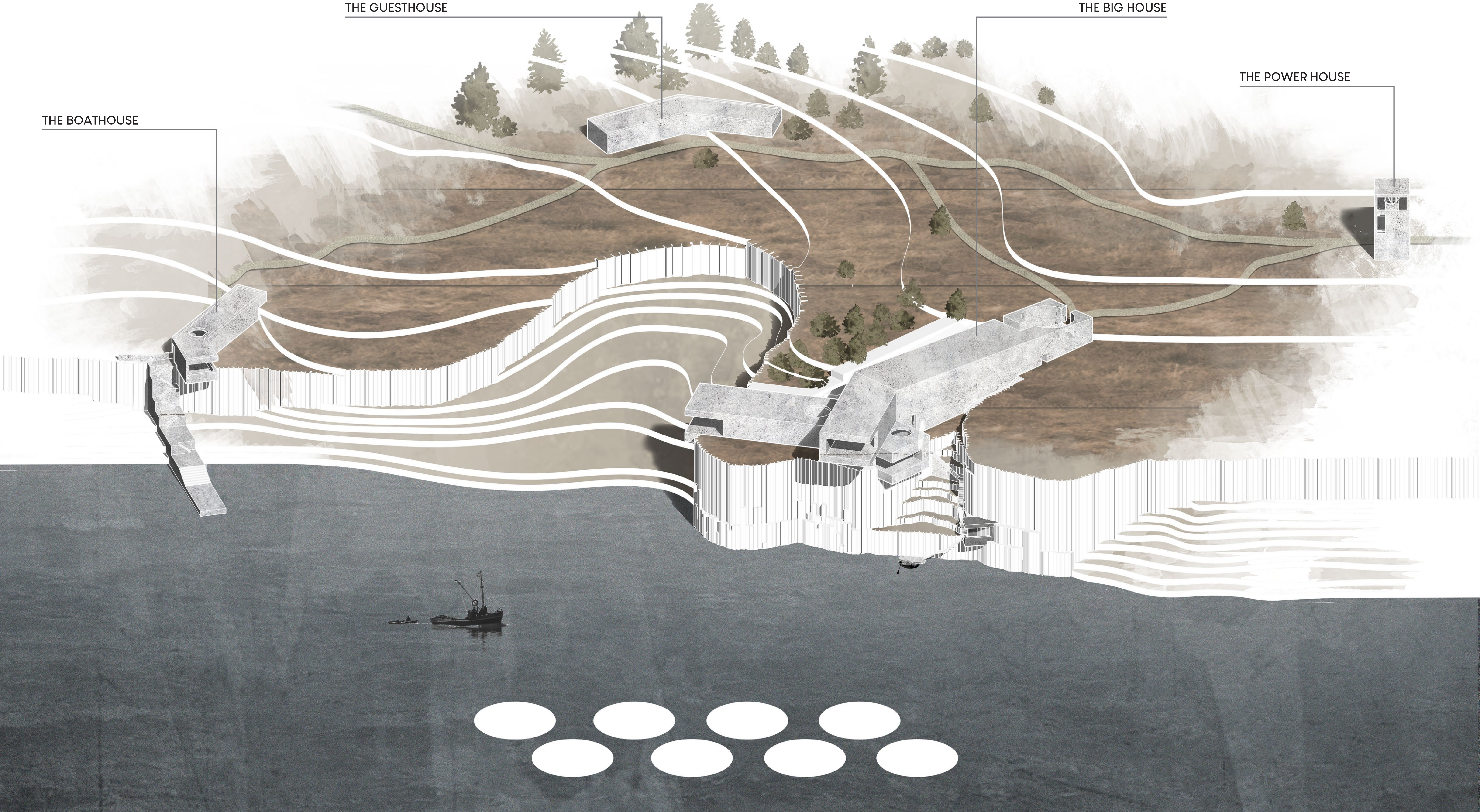
3. THE GUEST HOUSE
This building offers accommodation to possible tourists. It consists of four self functioning units with their own kitchen and bathroom. Additionally, these rooms might be used to house new residents of Ulva who are still building their new home.

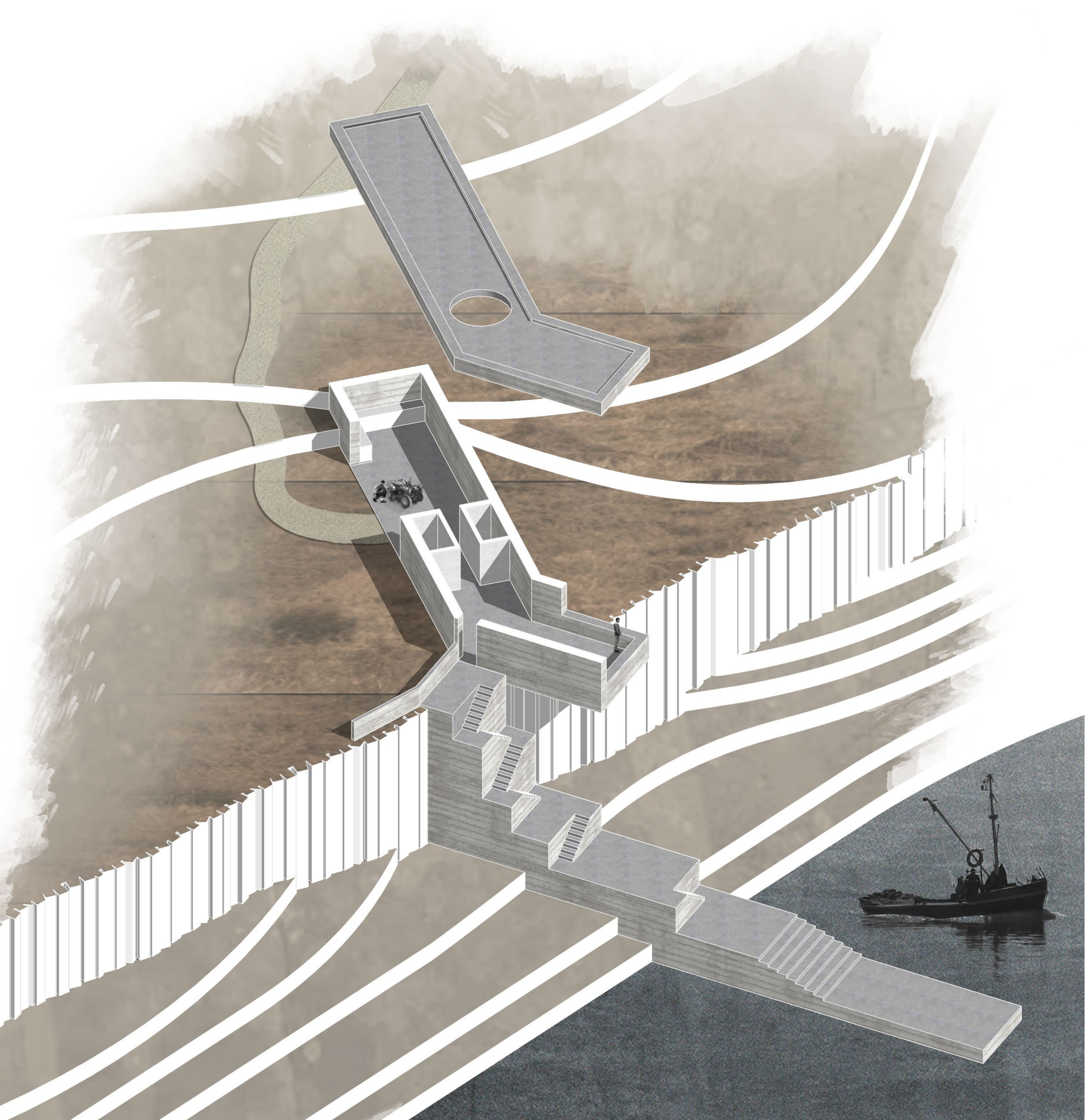
4. THE BOAT HOUSE
The most Western building of the ensemble is the boat house. Here, the cliffs are less high and much less steep. Therefore it offers a much easier transition to the water, and a dock for the boats of the residents. The building doubles as a view point of the cliffs, and it functions as a smalll workshop for the island community to work on their boats and their quad bikes.

5. THE BIG HOUSE
The main building of the ensemble is the Big House. Here a space is created for two families to live in. Almost half of the floor area of the building can be made accessible for the community of the island at large, so that it might double as a community centre.

REMOTE LIVING

ARCHITECTURAL ENSEMBLE





THE BOATHOUSE

The boat house provides a dock for the inhabitants of Ulva on the South side of the island. From here, the oyster farms can be more easily exploited. This dock will also serve as the base from where fishermen will depart. The dock is closer to the open ocean, and offers on-site storage for those who need it. The architectural language in terms of materiality and shape are a derivative of the main house itself as was determined in the form study.

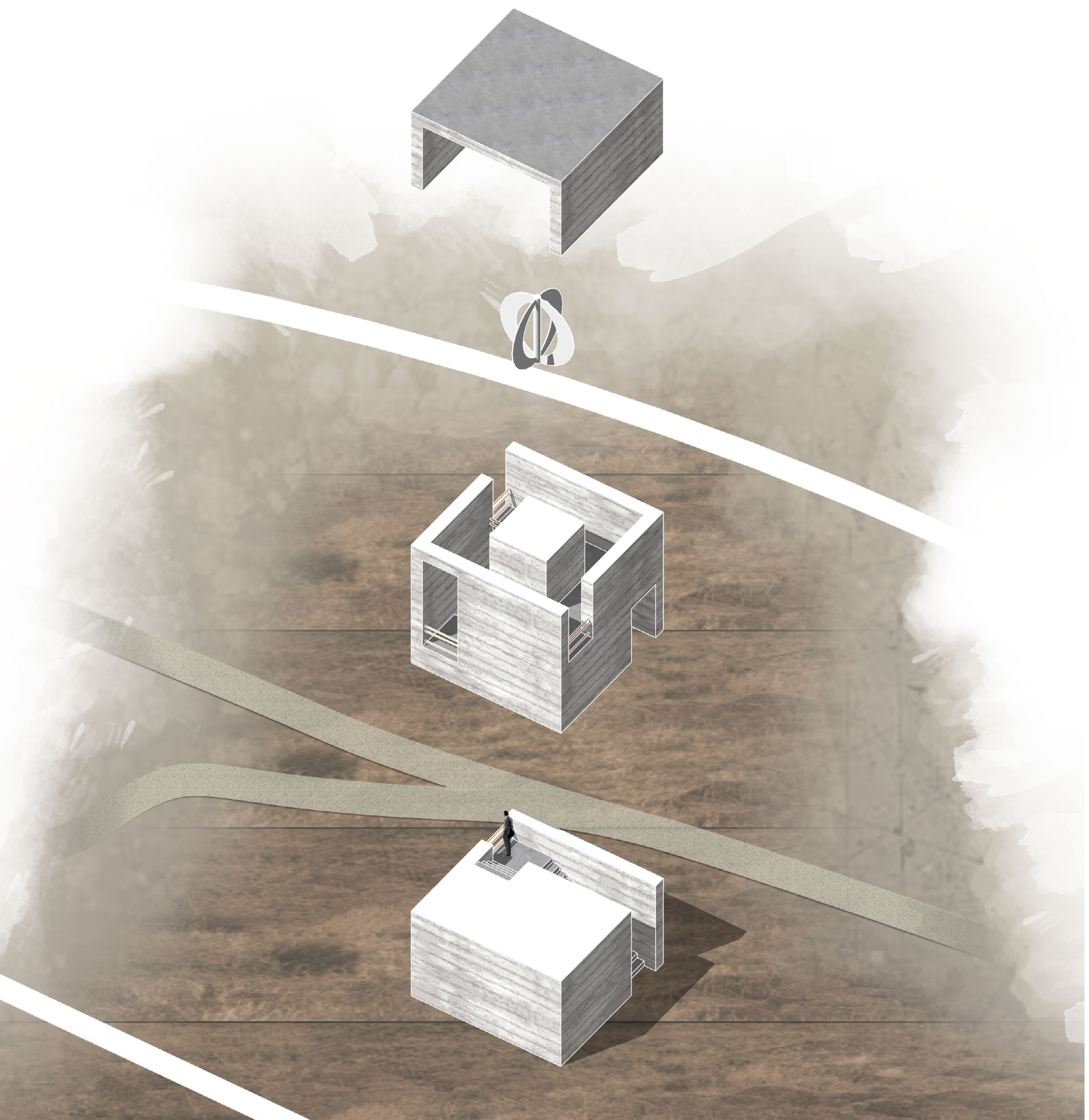
The restaurant at the Ulva ferry landing is gaining a reputation for its fresh seafood cuisine. New inhabitants of Ulva can make use of this by providing them with freshly caught seafood. Part of the captured fish is intended for own use. A possible surplus in seafood can be exported to the isle of Mull.

Besides serving as a dock, the South end of the Boat House can be used as a viewpoint for tourists who want to get the perfect picture of the basalt column cliffs. It offers a nice place to hang around for a while and have a picnick with a magnificent view. The picture that is used for the cover of this book and on page 238 can be taken from the dock of the Boat House

The North end of the Boat House doubles as a workshop. A workbench with all tools will be present, and it will offer a place for the residents of Ulva to work on their motorised vehicles, or even on their boats. This is a much needed addition to the island, as we learn from the quote below:

"There is a saying that if anything mechanical stops working on Mull, it will end up on Ulva."

(Andoran House, 2016)



THE POWER HOUSE

The most Eastern building of the ensemble is a small tower that offers a beautiful view over the ensemble of buildings and the cliffs that make the location so special. The building mainly consists of a staircase that leads to small platforms, with each their own unique framed view. The highest point gives a clear view to the West where the rest of the buildings are located and the South where the ocean and beyond that the peaks of Mull can be seen.

The name of the little tower is derived from its other function, namely it generates electrictiy by harvesting the strong Southern winds. A small windmill on a vertical axis converts the wind into electricity for the Big House and the Boat House. The energy is stored in batteries in the Powerhouse itself. From here, all electricity is re-distributed to the other buildings of the ensemble.

The Power House also acts as a small watertower for the architectural ensemble. It is located on a higher elevation than the other buildings, and in its centre there is enough space to store the water. The elevation results in pressurised water for the other buildings.

THE GUESTHOUSE

North of the Big House, a small guesthouse is created. It offers two rooms of about 30 square metres, and two rooms of about 35 square metres. The rooms can all sustain themselves, as there is a kitchen and bathroom in each room. Water for showering and flushing is collected on the roof when it rains, and electricity is provided by solar panels of the roof. The energy is stored in batteries in the Powerhouse.

The architecture of the Guesthouse is rather similar to the architectural language of the Big House. The heavyness of the rammed concrete is reflected, both on the interior and the exterior of the building. On the inside the space is softened by using obtuse angles, and by introducing softer textures such as wood in the interior walls.

The rooms of the Guesthouse will be rented out to tourists in the holiday season. In the off-season the rooms can still be rented out, by offering them to people looking for longer retreats. These people might be researchers, artists, writers, or people who just want to get away from the busy city life for a while. The occupants can make use of the amenities of the Big House.

When needed, the rooms can be allocated to new inhabitants of the island of Ulva, who might still be building their home and are looking for a temporary stay.

THE BIG HOUSE

The Big House itself offers space to two small families co-living in the house. Almost half of the space of the house is also accessible to the community of the island. This way, the Big House might serve as a community hub, where people come together to socialise, to work, and to plan the future of Ulva.

On ground floor, various spaces are opened up towards the shared patio. These spaces are used for a variety of communal functions. The auditorium offers space for performances or meetings, while the communal interior space can be used for indoor meetings or as flexible work space for the community of Ulva.

Upstairs, the more private functions can be found, such as the bedrooms. The private and communal functions are separated by an elegant double staircase.

1. The auditorium
2. Communal space
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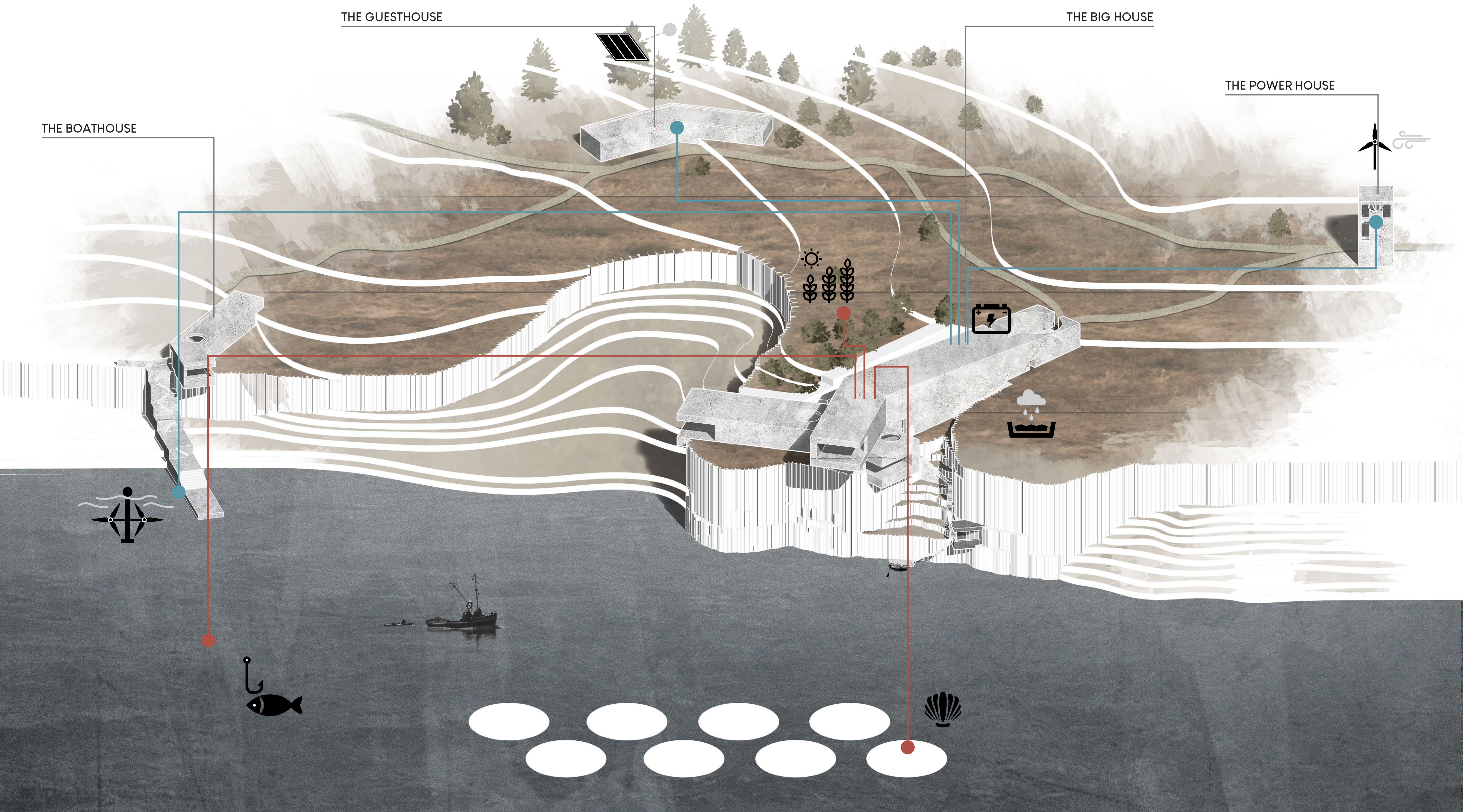
5. Central staircase
6. Living space
7. Study
8. Spa
9. Storage
10. Gym
11. The kitchen
12. Dining space
13. Master bedrooms
14. Guest bedrooms
15. Water tank
16. Garage

REMOTE LIVING **SELF-SUFFICIENCY**



ELECTRICITY & WATER

To achieve a high level of self-sufficiency for the entirety of the architectural ensemble, various measures have been taken. It is important that the way towards self-sufficiency is achieved in a sustainable manner. One of the problems with most renewable energy sources, is that they can be somewhat irregular or inconsistant in thier output. To combat this challenge, three sources of renewable energy will provide the required electricity for the ensemble. On top of that, the electricity will be stored in batteries, so that even in the event of none of the generators producing any output, electricity will be present.

The first source for the electricy has already been shortly discussed, as it is an integral part of the viewing tower that was consequently named the Power House. It houses a windmill that is attached on a vertical axis. The windmill faces South, and due to the strong and always present Southern winds, it will help produce a significant amount of the needed electricity.

The second source comes from the sun. Solar panels will be placed on the flat roof of the Guesthouse. About 150 square metres of panels can be placed here, providing more than enough electricity, especially in summer months. The angle in the building places the panels on the Southwest and Southeast respectively, which helps provide electricity during the entirety of the day more efficiently.

Below and along the docks of the Boat House, devices will be installed that harvest tidal energy. This provides a rather consistant output of electricity throughout the day and night. Blades that act similar to those of windmills will drive a generator, and a buoyant volume that is lifted up by the tides will provide additional output of electricity.

Any surplus in the energy output can be redirected to other buildings on the island. This way the initial step is taken towards creating a central main net for the whole of Ulva.

Additionally, the flat roofs of the buildings will collect rainwater. In the Scottish climate this proves a very useful tactic as there is a lot of rain to be caught. The Power House may act as a water tower, as it is elevated higher than the rest of the buildings, and therefore naturally acts as a pressuriser of the collected water.

REMOTE LIVING
SELF-SUFFICIENCY

FOOD PRODUCTION & INCOME

Besides being able to generate their own electricty and collect their own water, it is important for a remote community to produce most of their own food in a sustainable manner to be able to achieve self-sufficiency. On the East of the island, cattles have been released as a part of the new initiatives that the communal owners have launched. Additionally, The Southeast of the island has excellent conditions for irrigation, and can prove useful in providing the island at large with some of the basic foods they need. The surplus can be exported to Mull, which generates income for the residents of Ulva.

Other ways in producing food on Ulva include harvesting the fruits of the sea. The restaurant at the Ulva ferry is increasingly gaining a reputation for its fresh and well prepared seafood. This offers opportunities for the residents on the island. Therefore, the Boat House and the Big House in the ensemble have received their own docks, to make it easy for the residents within and around the ensemble to exploit the ocean. Additionally, the proposed ensemble is located right in front of the existing oyster farm, which can thus be managed and exploited much easier from the Big House.

The Big House itself is designed in such a way that a protective space within the wedge is created, away from the strong winds. This allows for small vegetable gardens to be created and used in the provision of fruits and vegetables for the residents and guests of the Big House.

Besides producing income from the surplus of food that may be harvested from the sea and the land, tourism is an important finincial sector for Ulva. The idea is to attract people all-year long to the ensemble in some shape or form. During Summer time, one- or two-day trips are the most preferred options for tourists on Ulva. Tourists can be accommodated in the Guesthouse, where four bedrooms are present. During the Summer, the Big House will mostly be opened up, meaning that tourists can enjoy its amenities. The pool can be used with its sauna, performances in the Auditorium can be attended, and cooking classes can be joined in the kitchen.

Additionally, two spare bedrooms in the Big House can be rented out to tourists who want to experience Ulva more as a retreat. They can help along in the daily tasks of the residents to keep the place self-sufficient, which in turn might seduce more people to join the Ulva community.

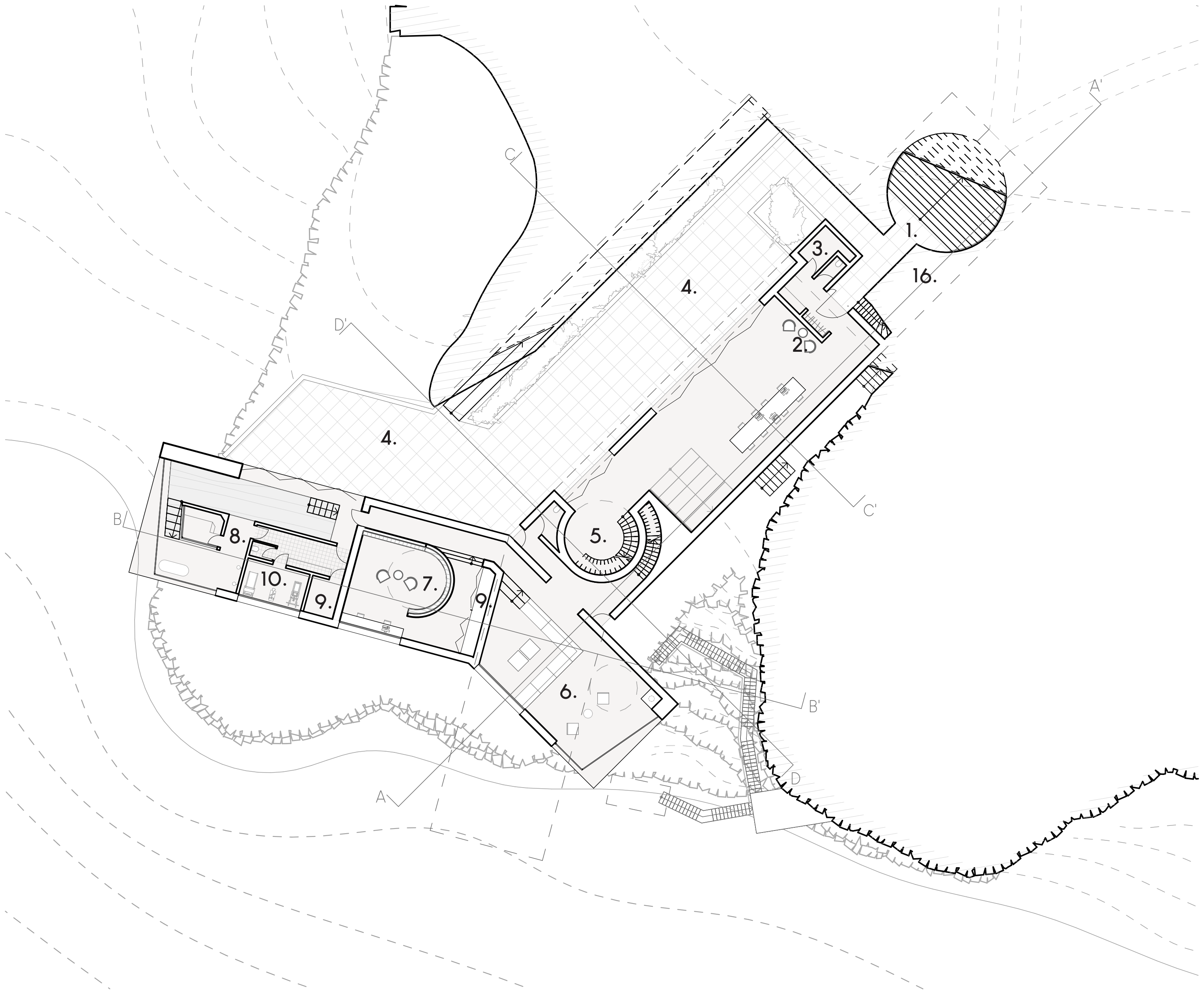
In Winter time, ferry's are more irregular, and tourism more scarce. The residents might try to focus more on the long-term artists' retreats, where people get to enjoy the Big House amenities while being away from the city life for a period of time to work on a book, a research project, or on themselves.

THE BIG HOUSE

The most important building of the ensemble, is the communal Big House itself. Here, the residents spend most of their time, and here is where the community of Ulva will find a place to come together.

For its design, the main considerations were the location and its inherent qualities, and the influence of the climate. The concept is to create a building that creates an oasis for its residents and the community, that is protected from the rough climate, while capitalising on its extraordinary location by creating a dramatic composition that compliments the location.

While the building itself appears to be a heavy solid mass to emphasises its protective character, it makes optimal use of its surrounding with small gestures. The buildings points towards the most scenic views, and the windows are cleverly placed, offering panoramic views in all degrees.



Ground floor plan 1:400

GROUND FLOOR

The entrance to the Big House can be found on ground floor level. It is accessed through the auditorium. The auditorium is basically a wide staircase that slopes down with the natural slope of the site, and leads down into the belly of the building. The staircase will double as a auditorium when the weather allows for it. It is protected from all sides due to its circular shape. Here, in warm summer afternoons movie nights can be organised for the whole community. Performances can be given by locar artists, and ideas on how to improve Ulva can be shared here.

The belly of the building is the communal space. The space is large and open to accommodate any activity. A smaller auditorium can be found here, for smaller meetings that need to be indoor. During the day it might be used as a flexible work space, for the residents who work remotely, or have an internet bussiness. During the evenings activities can be organised here.

When the weather permits it, the communal space can be opened up to the patio, doubling the size of the space. A perfect place to watch the sunset while a yoga session is organised to strengthen the communal bond of the Ulva population.

The shape of the building offers a protective outside space in the wide V that is created. The wind-free space allows for the irrigation of crops on a small scale, to provide for the residents.

The main element that elegantly separates the communal functions from the private functions is the double central staircase in the heart of the building.

On the Southeast end, the private living space has the most spectacular view of the whole building. It offers a spectacular view along the basalt column cliffs towards the snow covered peaks on Mull.

Right next to the living space, the study can be found. It consists of some more intimate work spaces surrounded by books and some comfortable reading spots.

On the Western view a spa is created. It boasts a pool, and a sauna. During the summers, the pool can be opened up to the outside, and be shared with the rest of the community. As a part of the spa, a small gym is provided. This will prove useful for the residents during winter times, when outside movement is limited, and excercise needs to be gotten in a different manner.

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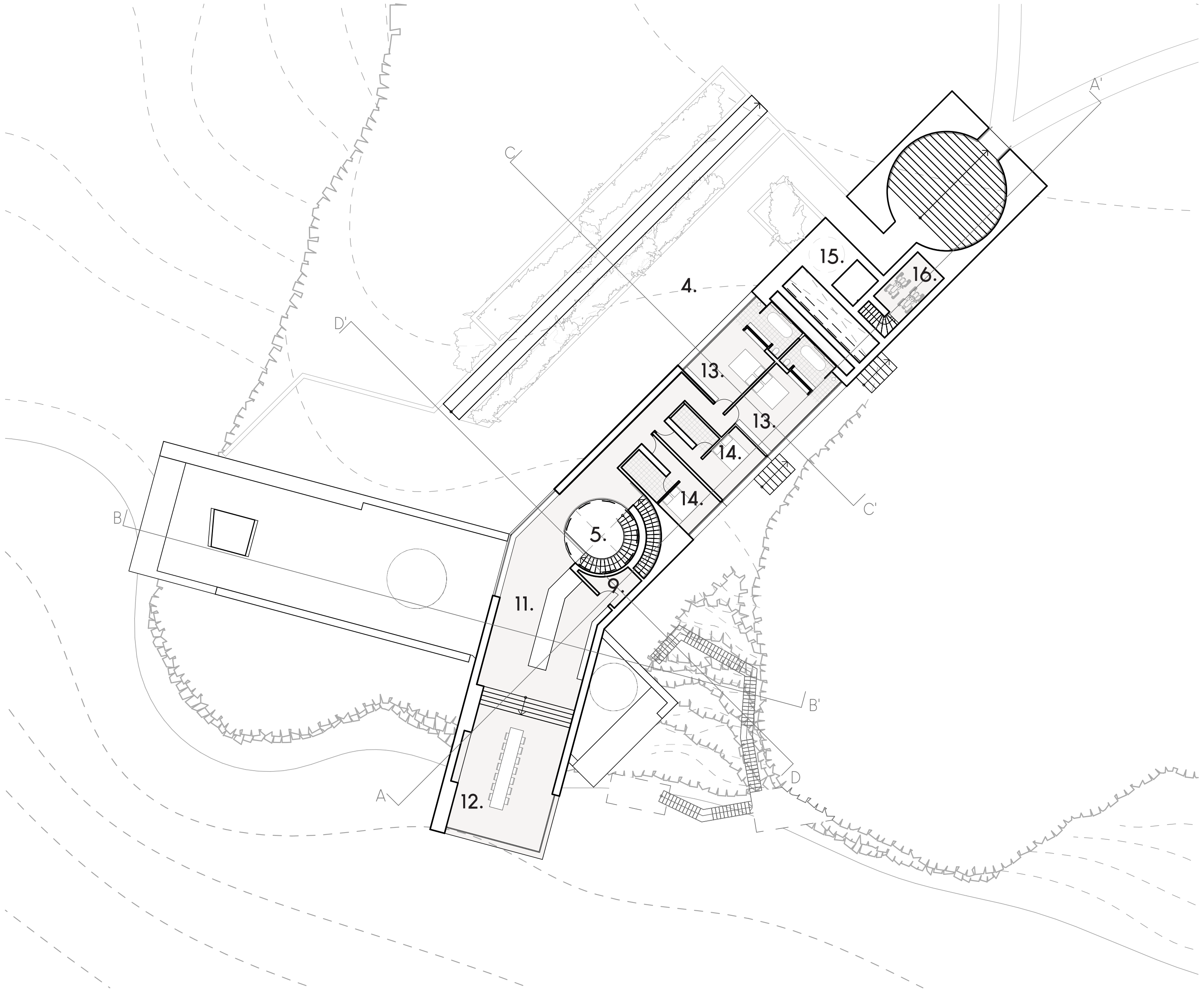
14. Guest bedrooms
15. Water tank
16. Garage

FIRST FLOOR



First floor plan 1:400

The first floor of the Big House houses some of the more private functions, such as the bedrooms. However, from the central staircase the kitchen can be accessed, which can be allowed to be open to the community whenever. With enough room to host cooking classes and dinner parties. The kitchen faces West, with large windows that overlook the communal patio and vegetable garden, and beyond it the island itself. The dining room is elevated about half a metre above the kitchen floor, with a panoramic window on the Southeast. A small fireplace along the dining table will make this a comfortable space to be all day long.

The master bedrooms can be found on the other side of the central staircase, with easier access to the staircase that leads down to the living space. The master bedrooms have large bathrooms and beatiful views of the island. Here the two co-living families take their residency.

The guestrooms can be rented out to tourists. They will get the full self-sufficiency experience, as they can help along manage the vegetable garden and the oyster farm. They will have their own bathrooms, and full access to the amenities of the Big House.

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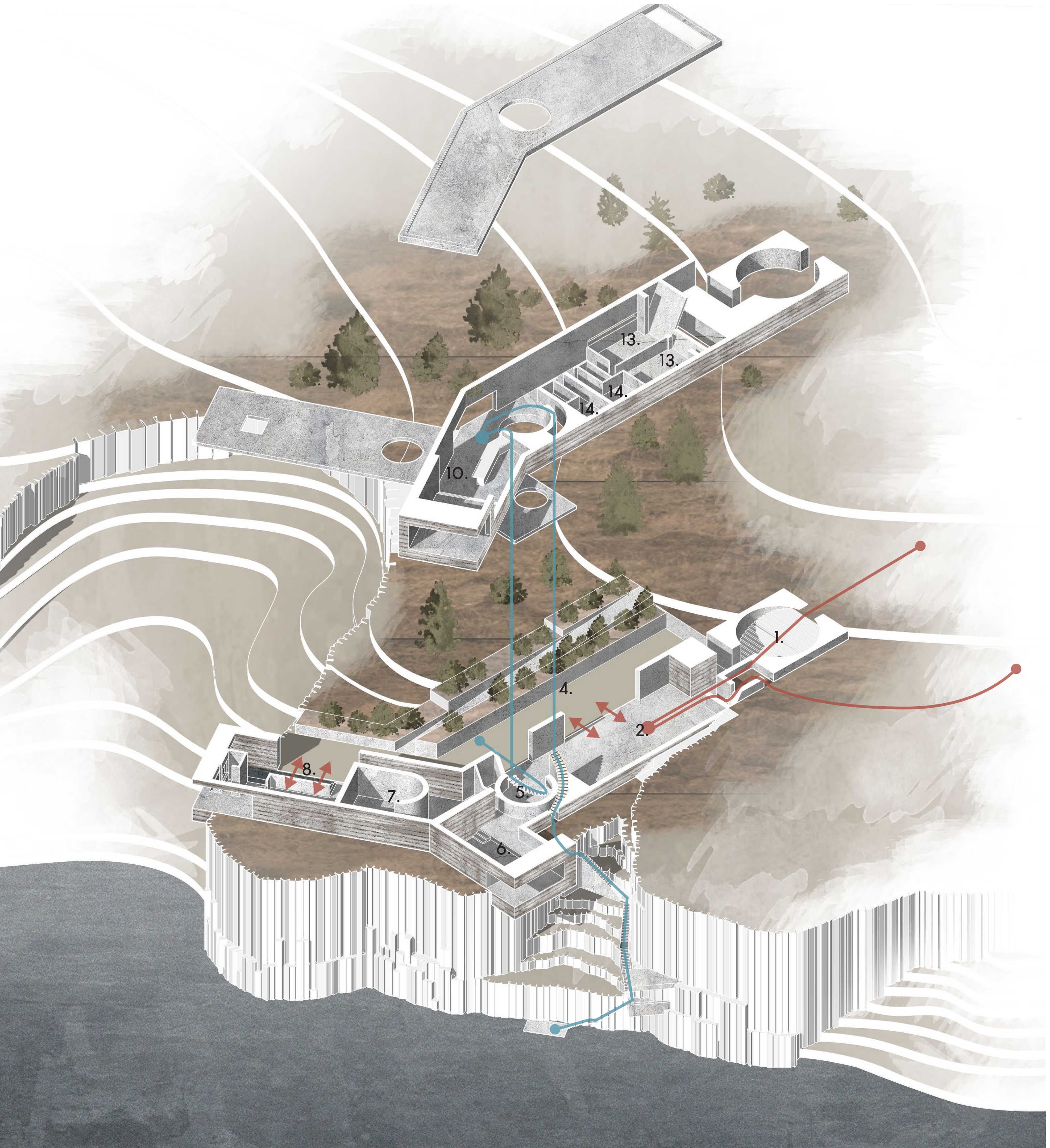
ROUTING



The main challenge for the interior of this building was to integrate the many different movements into a single, elegant routing. A building on a location as remote as this one requires a way to operate as self-sufficient as possible. This means in practice that the building offers various ways of providing resources to its residents, and possibly to the island community at large. A vegetable garden is provided within the protective oasis that the house harbours. On top of that, a small dock provides access to the open sea and to the oyster farm in front of the coast of Ulva. This route can be used both for fishing, as well as for restocking. The blue lines in the drawing represent these provision routes.

The red lines show how the building is being entered, either on foot, or by quad bike. A large auditorium slopes down along with the natural shape of cliffs, into the house. In its side, a small garage is created that creates space for the motorised vehicles. These routings obvisously can also be used for restocking.

Besides the different routings that provide access to the building, a complex internal program that is both private and communal adds to the complexity of the functioning of the building. An elegantly designed central staircase is used to direct all these different routings. It separates public from private, and makes sure that all restocking and provison routes end in the kitchen, which is large enough to cook for multiple families, or to provide cooking classes to tourists with the locally sourced and grown produce.

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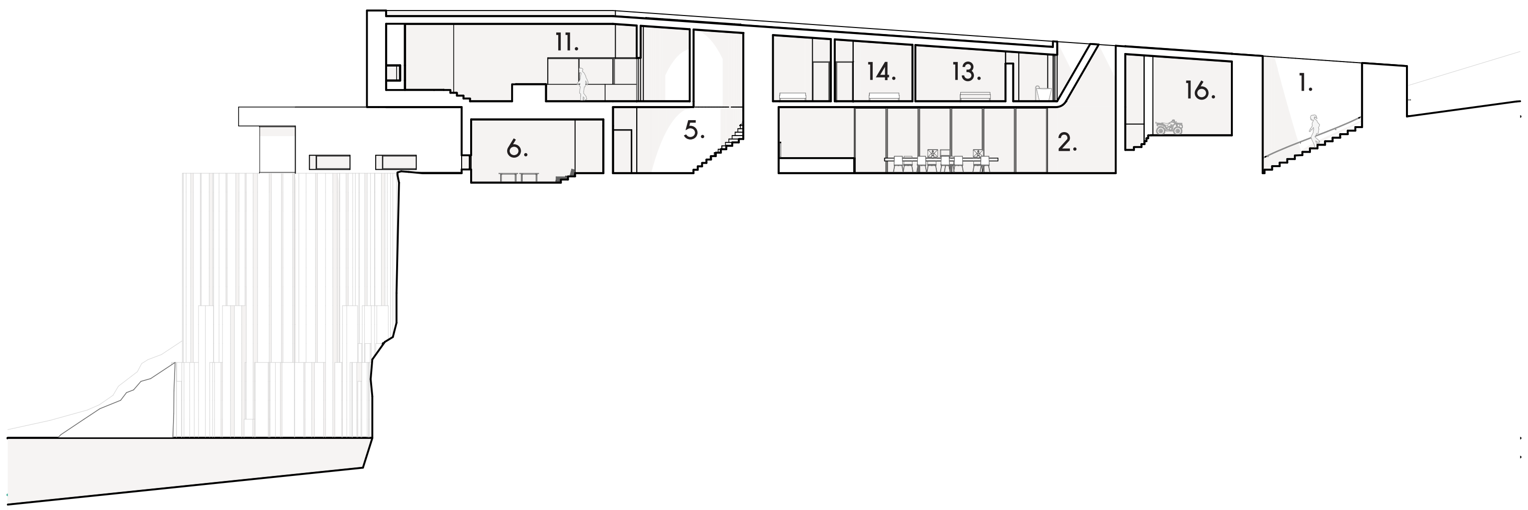
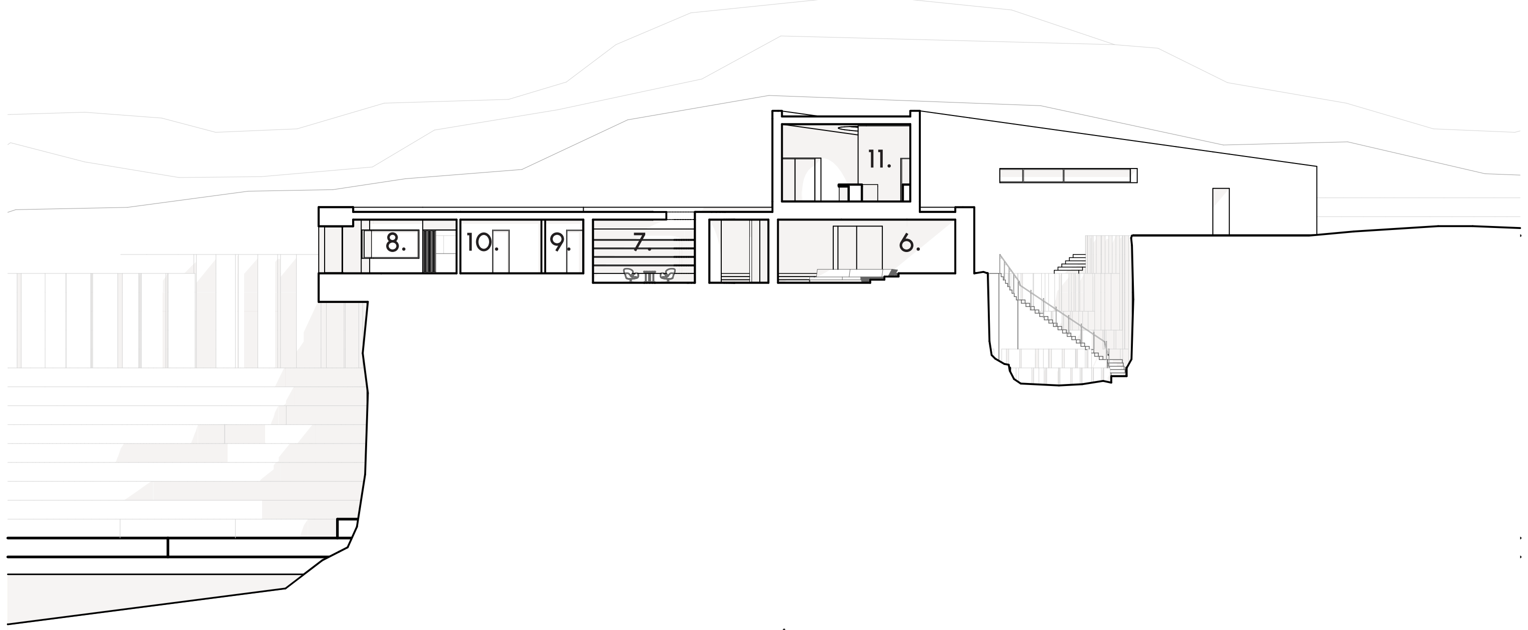
REMOTE ARCHITECTURE
SECTIONS



Section AA' 1:400



Section BB' 1:400

SECTION AA' & BB'

In section AA' the way the auditorium leads into the belly of the building along the natural slope of the terrain is demonstrated. Slightly elevated above it, is the garage where the quad bikes can be stored. A narrow staircase leads to the same entrance as that of the auditorium.

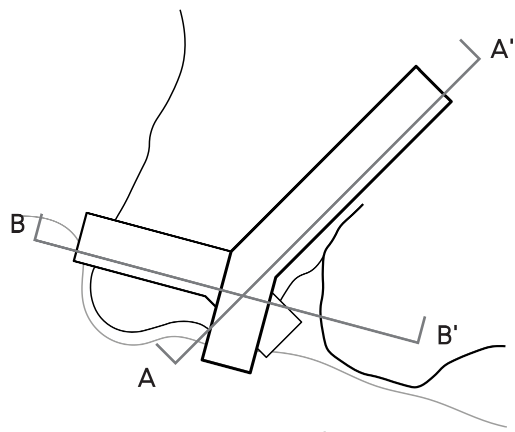
On ground floor level the communal space can be found. It offers a panoramic view towards the West, where the communal patio is located. Additionally, light is being cast into the space by a void that leads to a skylight.

The living space and the kitchen can be accessed by the central staircase, which acts as the barrier between communal and private spaces.

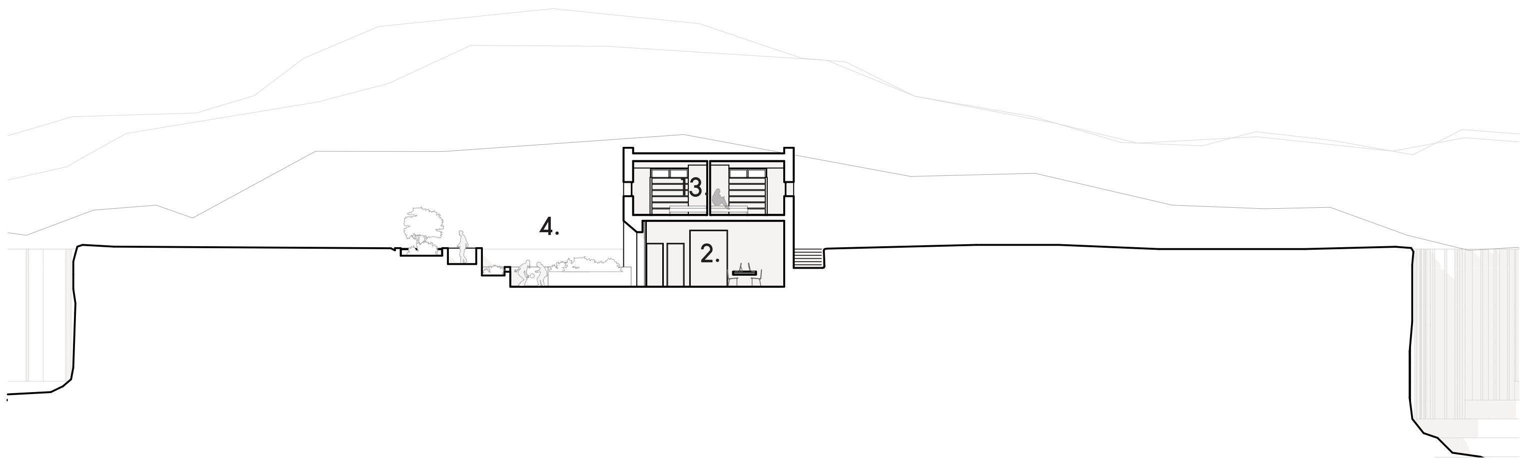
Upstairs, the four bedrooms are found. The master bedroom offers a large ensuite bathroom that can be opened up towards the outside by a sliding glass door.

Section BB' is made in the other direction, giving more insight in the more private functions on ground floor lev- el. Just below the kithen, the living space can be found. This space consists of two areas. The area in the section is slightly sunken into the ground, and allows for a larger party of people to sit down and socialise or watch tv. The slightly elevated part of the living space is more focussed on the view, and offers less seating places.

Left of the living space is the study. Here, a small library can be found, along with desks to create a more formal work-at-home setting during the day, and a relaxing spot to read in the evening.



1. The auditorium
2. Communal space
3. Building services
4. The patio & vegetable garden
5. Central staircase
6. Living space
7. Study
8. Spa
9. Storage
10. Gym
11. The kitchen
12. Dining space
13. Master bedrooms
14. Guest bedrooms
15. Water tank
16. Garage



Section CC' 1:400

Section DD' 1:400

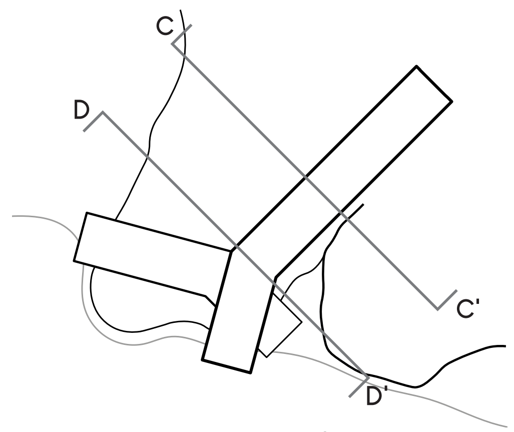
SECTION CC' & DD'

Section CC' shows the low windows in the bedrooms. The windows are only 750 milimetres high, but they are about four metres in width. The offer the perfect panorama of the island and the ocean as seen from the bed.

Below, the communal space is shown. A gesture towards the outside is made by the tapered concrete beam that allows for the 12 metre wide panoramic folding doors to open up the space.

Outside, the terraced patio can be seen with some of the planter boxes in place. In these planter boxes vegetables and fruit can be grown by the residents. A slope provides access from the lower patio to the slightly higher ground level of the site.

The last section, section DD', shows the building floating between the two cliff plateaus. In this tear between the two plateaus, a staircase is created that leads down to the small dock for the residents of the Big House. A small dock house is created just above sea level to allow for fishing from the shore.



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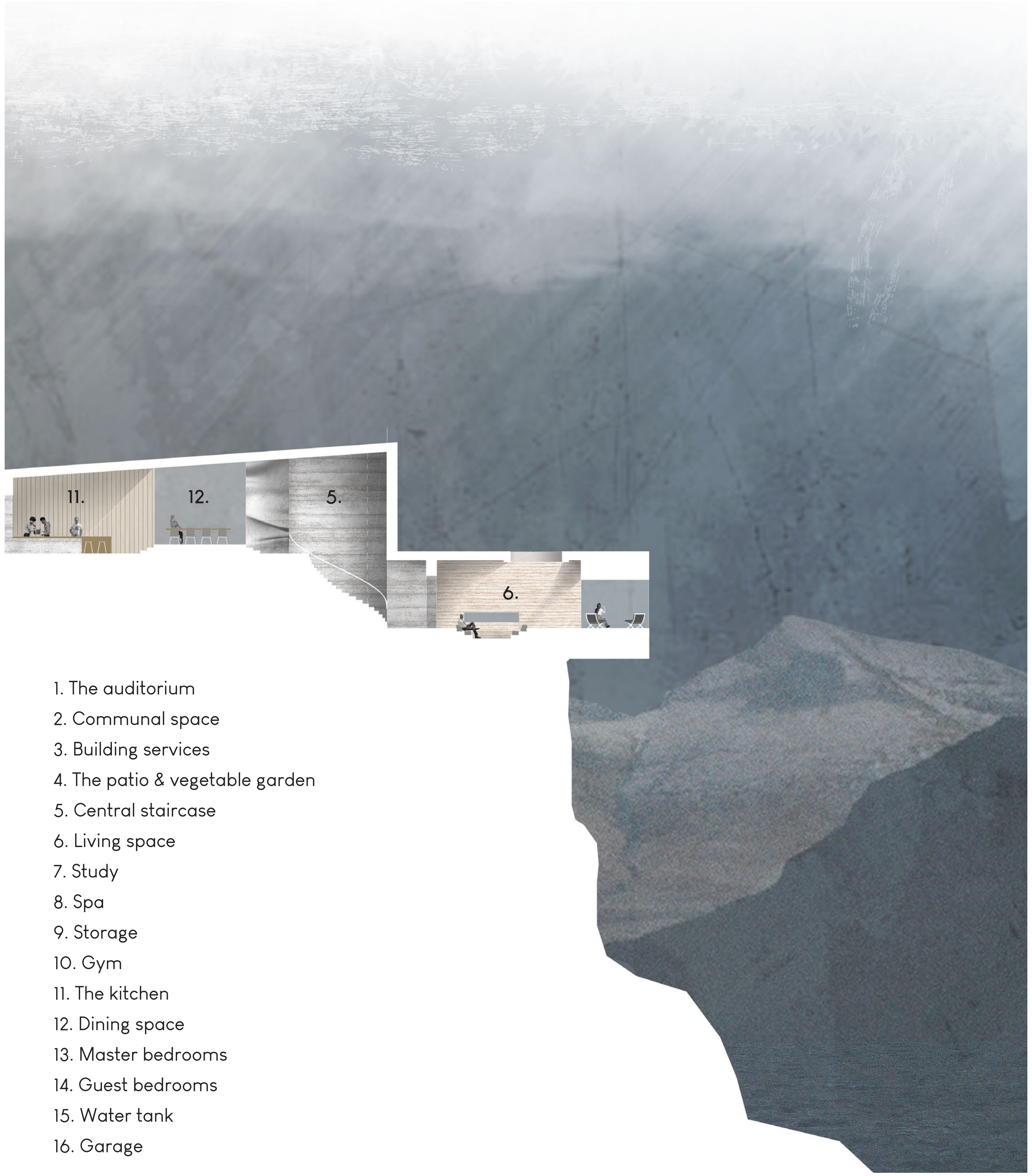
14. Guest bedrooms
15. Water tank
16. Garage

SCHEMATIC SECTION

In this drawing, the movement through the Big House is illustrated in a schematic section. One starts in the Auditirium, which leads down into the belly of the building. When entering into the building, plenty of daylight is ensured by the skylights from above. This creates a contrasting experience for the entering sequence, as the building itself presents as massive, but the interior feels very light. In this communal first half of the building, the connection towards the protective oasis in the centre is plentiful. Folding doors provide access to the shared patio with vegetable garden.

In the heart of the building, the central staircase is found, which leads up to the first floor, where the kitchen and dining are located. When going back down to the ground floor via the secondary stair in the central staircase, the space leads towards the more private spaces for the residents. This staircase presents itself as more narrow and less light, signifying the movement towards a more intimate space. The living space on ground floor has the most dramatic view, which a special viewing corner is designed for. The other half of the living space is more intimate and aimed at socialising.



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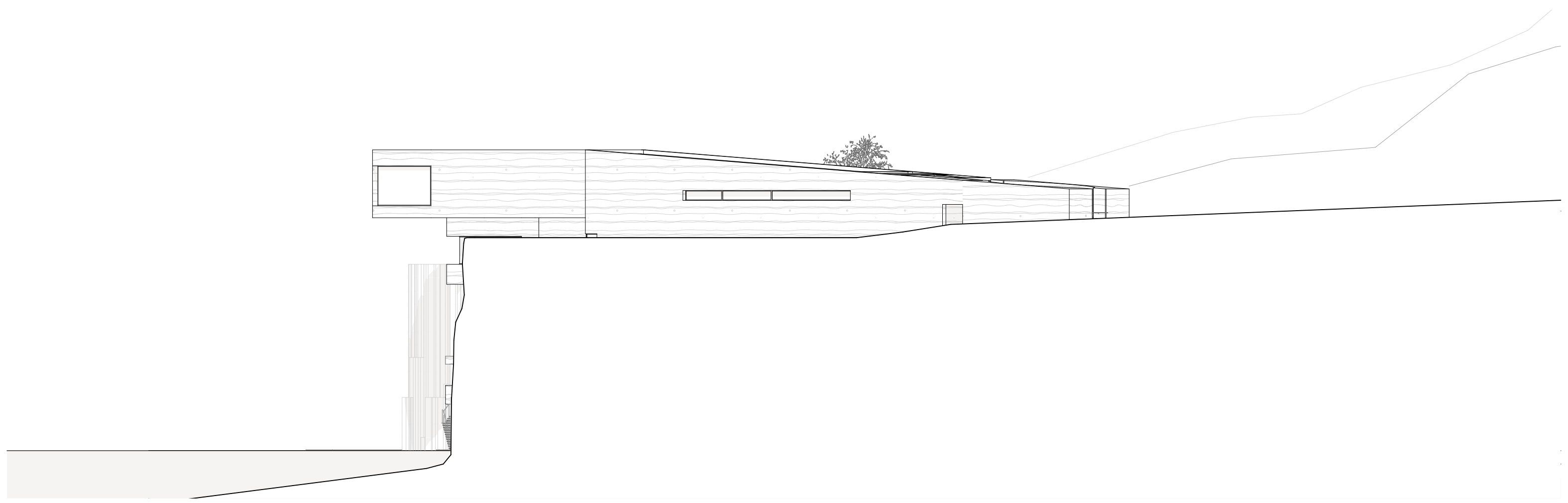
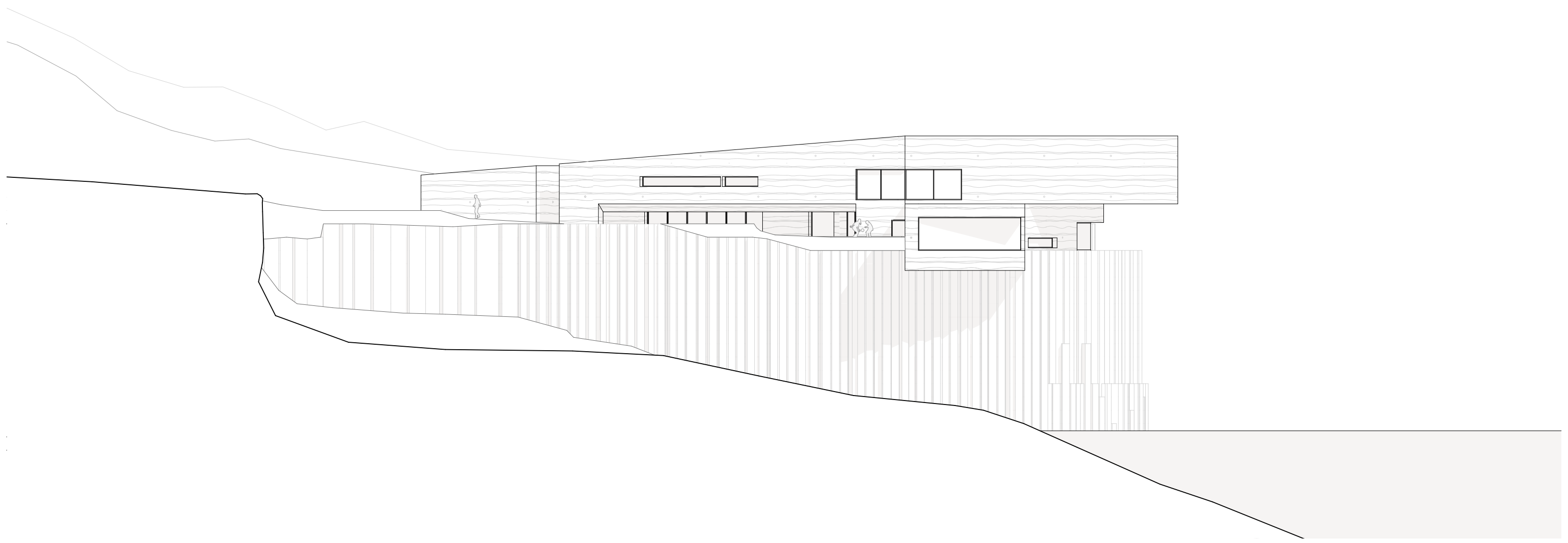


East elevation 1:400

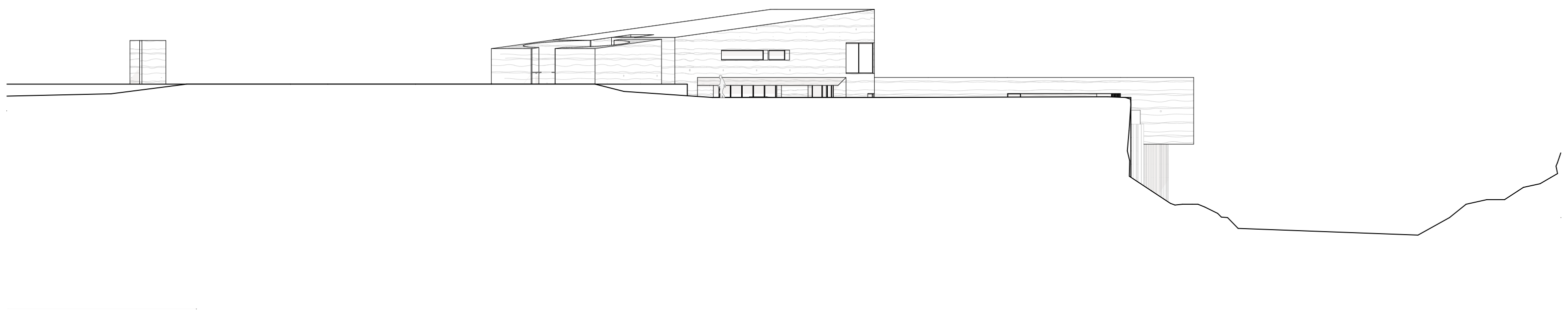


West elevation 1:400

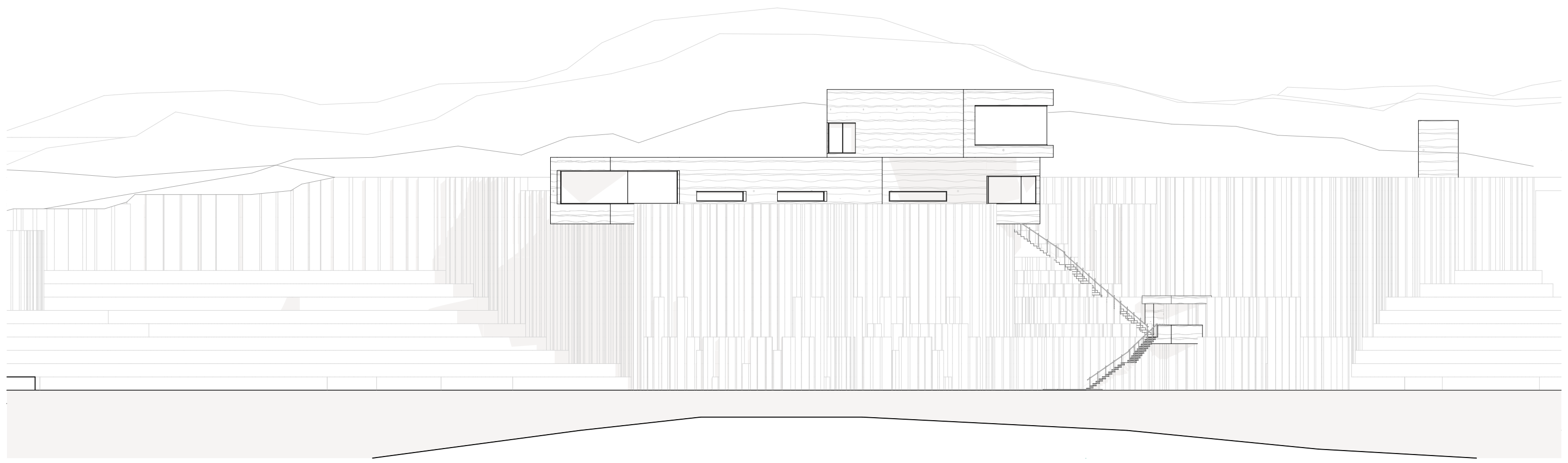
EAST & WEST ELEVATIONS

What can clearly be observed in both of the elevations is the downward slope of the building towards the island side. This gesture is a reaction to the downwards slope of the terrain towards the cliff edge. In this manner, the building seems to naturally emerge from the ground, and rise above the cliff in the gesture that is the overhang.

The horizontal character of both the building shape and the building materials become more apparant. They offer a strong contrast to the vertical columns of the cliff. In these drawings, the horizontally oriented panoramic bedroom windows are clearly shown.



North elevation 1:400



South elevation 1:400

NORTH & SOUTH ELEVATIONS

The North elevation makes more clear how the building seems to emerge from the ground, and rise above the cliff. The lower beam that is situated at the end of the cliff, almost dissapears from view from this angle. This is again due to the downwards sloping terrain. From this angle, the building seems much more humbly placed in its context.

In the South elevation the fishing shack and the dock can clearly be observed. It is a relatively long way up and down the stairs, so this dock can hardly be used for hauling cargo loads of supplies. For that purpose, the Boat House is conceived.

The process of ramming concrete.

RAMMED CONCRETE

The choice for the main building material has fallen on rammed concrete, as has been briefly explained earlier on. The technique of making rammed concrete was developed in the early 19th century, by adding cement to a moist mixture of natural stones and earth. The mixture is then rammed until a moisture film appears on top of it. Once the layer is hardened, the excess moist is removed, and a new layer of the earthly mixture is added on top and rammed.

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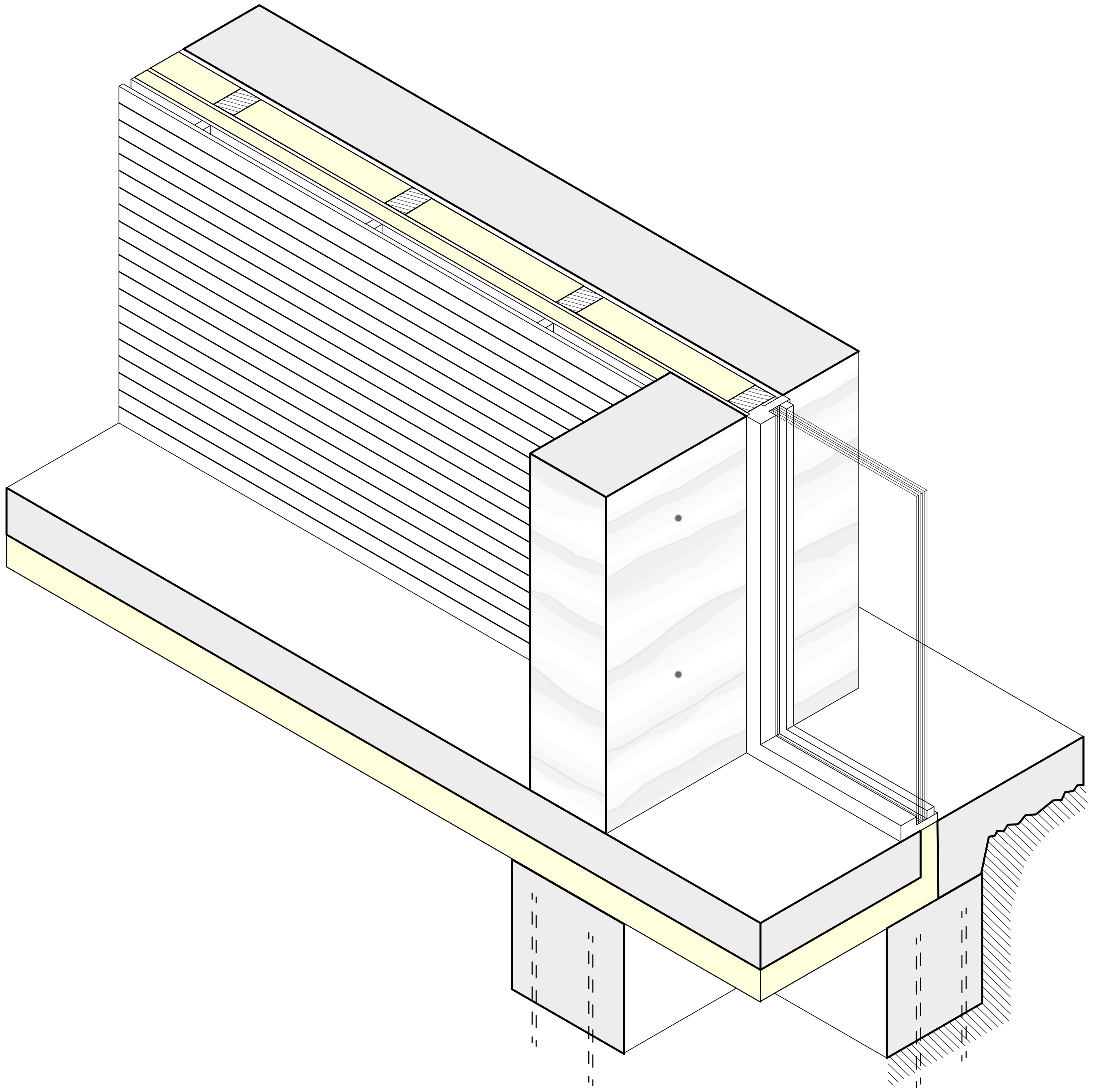
Then, in the early 20th century, reincorced concrete was invented, and the technique of ramming concrete soon became obsolete. Compared to reinforced concrete, rammed concrete has far inferior tensile strength, while producing rammed concrete is also much more labour intensive.

The technique seemed to have been forgotten for about a hundred years, but then this outdated technique gained new attention due to Peter Zumthor's Klaus Chapel. Local materials that could be extracted from the soil were mixed with cement, and the mixture was rammed by the hands and feet of local residents.

As a technique, rammed concrete is highly durable, and due to the fact that local materials are mixed with the cement, without adding reinforcement, it is relatively sustainable as well.

The basalt column cliffs of Ulva have a very distinct vertical expression. These vertical columns are being contrasted with the much more horizontally oriented beams that form the house. To strengthen the horizontallity of these shapes, the material is to emphasise this quality as well.

The choice was made to use rammed concrete for the task. Some of the major problems with the location of this building is the accessibility. Rammed concrete offers part of the solution, since not all concrete has to be poured in one go. Instead, every other day a truck can go on site and deposit a load of concrete. What gives rammed concrete its unique expression, is slightly changing the mix of the concrete with each pour, which can easily be done off site.



Construction detail of interior rammed concrete load-bearing walls.

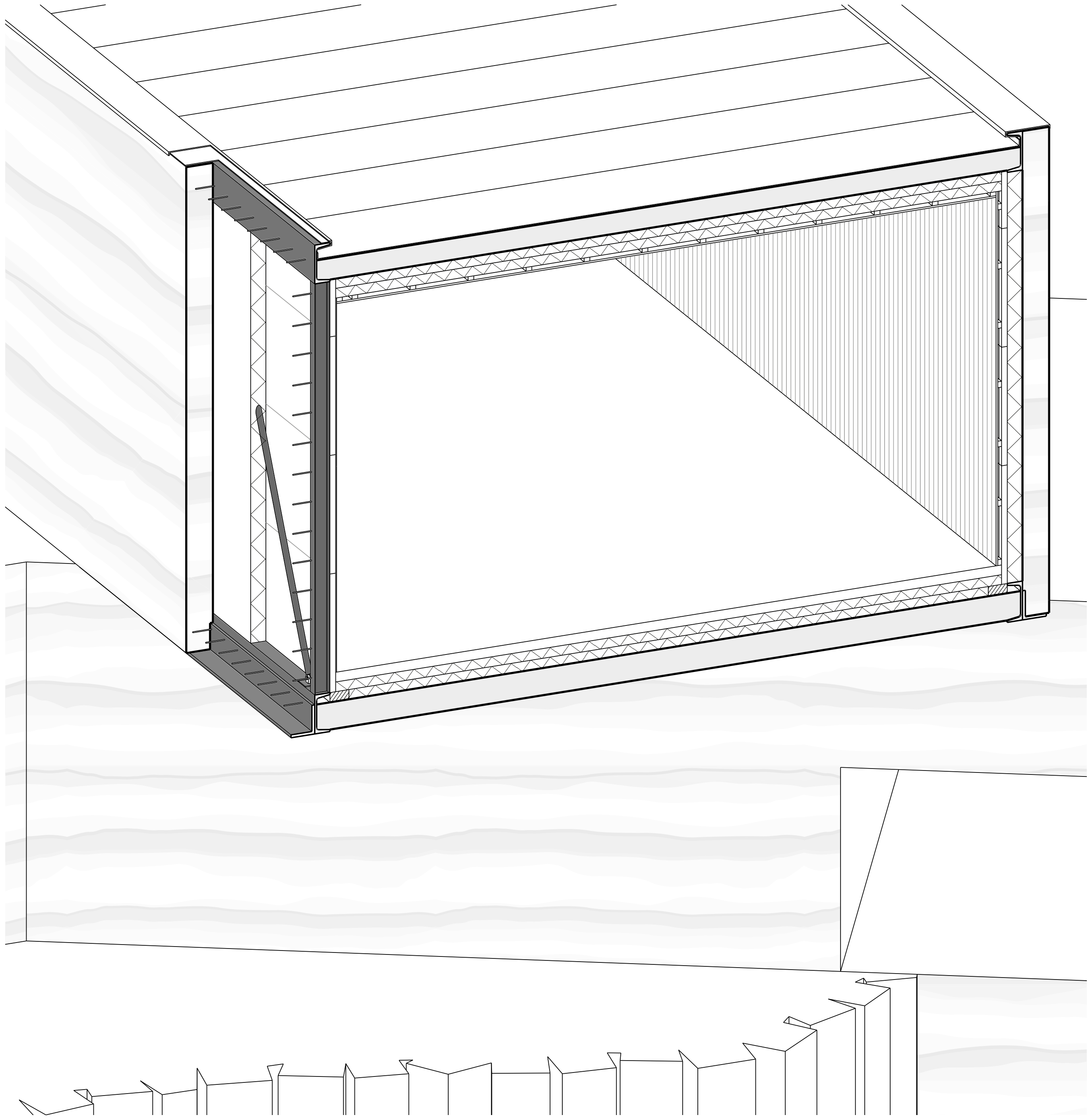
CONSTRUCTION PRINCIPLES

An important feature of the construction of the buildings, is that it is all labour intensive work. Many of the materials can for a large part be locally sourced, like the components for the rammed concrete and the cement plaster. The timber, both for the interior and for the formwork can also be locally sourced. All jobs can be given to local craftsmen, and the community of Ulva itself should be involved in the construction process as well. When they play an integral part in the assembly of the building, they will feel more as if it is a space of their own.

All the formwork for the slabs will be assembled on site, using locally sourced timber from one of the pine wood plantations on the neighbouring island of Mull. Local craftsmen will be hired to do the job, to stimulate the economy in the area itself.

The inner leaf of the formwork will be constructed like a timber frame wall, which will remain in position after the concrete has cured, and the rest of the formwork is removed. The inner leaf, which acts as lost formwork, will then be insulated, and rendered or finished using the timber that served its purpose as formwork.

The slabs can either be prefabricated, or poured on site. The floor slabs for the exterior flooring can be poured on site, directly onto the rock soil.



Construction detail of the overhang.

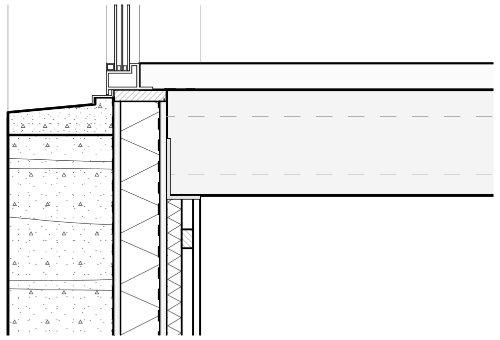
OVERHANG DETAIL

One of the more difficult parts of the building to engineer is the large overhang that hangs over the cliff's edge. The building material of choice is rammed concrete, which is almost impossible to reinfoce, which in turn makes this a difficult feat to execute.

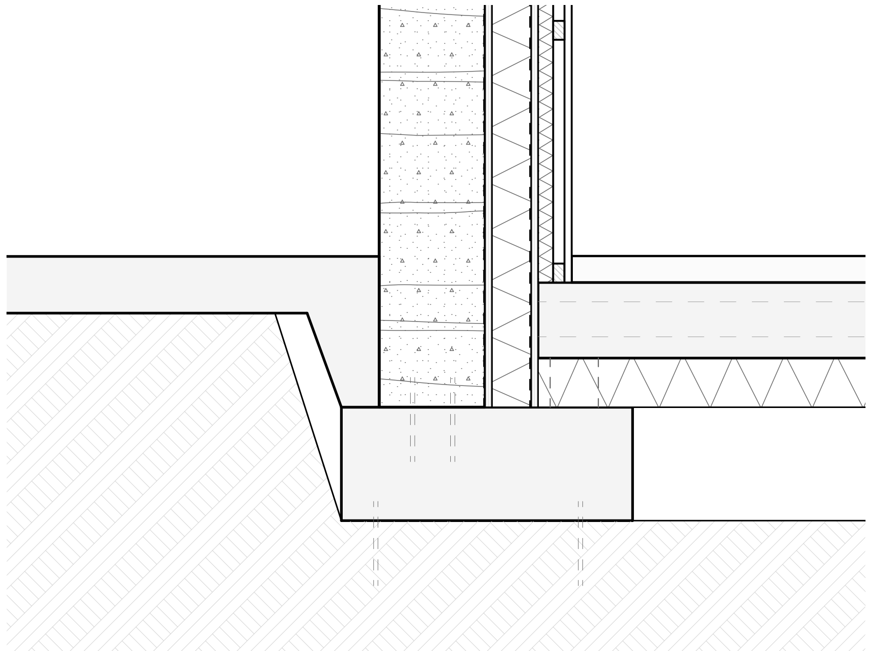
The idea is that here a steel truss is created, which supports the rammed concrete façade walls. The walls are secured to the steel frame by steel rebar that is attached to the steel frame when a new layer of concrete is about to be poured. The concrete will then attach itself to the rebar.

The insulation of the shell is on the inside, creating a box-in-a-box principle.

2D DETAIL



Construction detail of a window.
1:20



Construction detail of the foundation on rock soil.
1:20

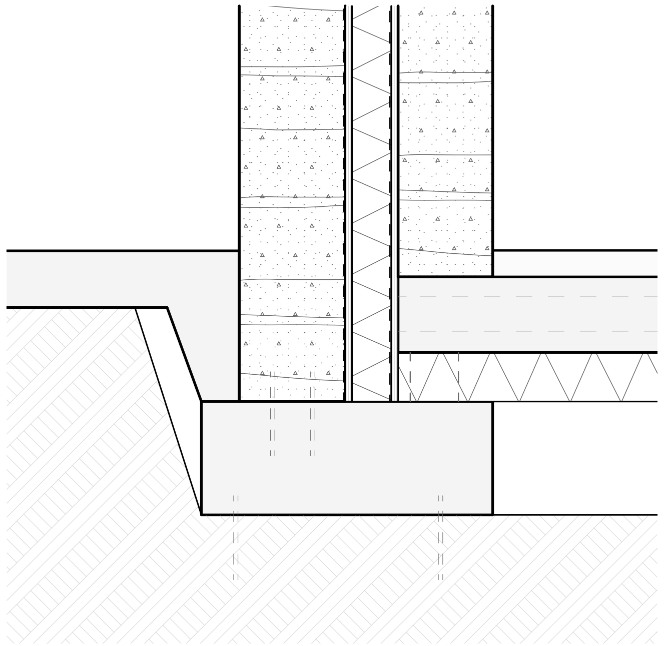
Due to the fact that the soil is made of rock, it is relatively easy to engineer the foundation. The top layer, which is mostly a clay soil, and a part of the rock layer need to be excavated. The clay can be reused later on for the pouring of the rammed concrete walls.

The strip foundation should be mounted to the layer of rock, for extra stability. For the exterior concrete floor, no additional foundation or other measures are needed. The floor can be poured on top of the rock soil.

The rammed concrete walls can be poured directly on the concrete foundation. However, first the formwork needs to be erected. The inner leaf of the formwork will be constructed using a simple timber frame wall, which will later act as the insulating leaf of the wall. In essence, this can be considered lost formwork, which remains to serve a purpose. The outer leaf of the formwork can be disassembled and cleaned once the concrete has hardened. It might then be used for the interior timber finishings.

One of the more difficult parts to design was the deep reveal of the windows. A prefab concrete window sill is needed on the outside, to ensure proper drainage of rainwater.

In some part of the building, the rammed concrete will also be the finishing material on the inside of the building, as seen in the image below. Here, an extra thick wall is thus needed. The rammed concrete in the interior will act as load-bearing elements for the concrete slabs for the first floor.



Construction detail of the foundation on rock soil.
1:20

Implementation of MORPHICS as an interior wall element.

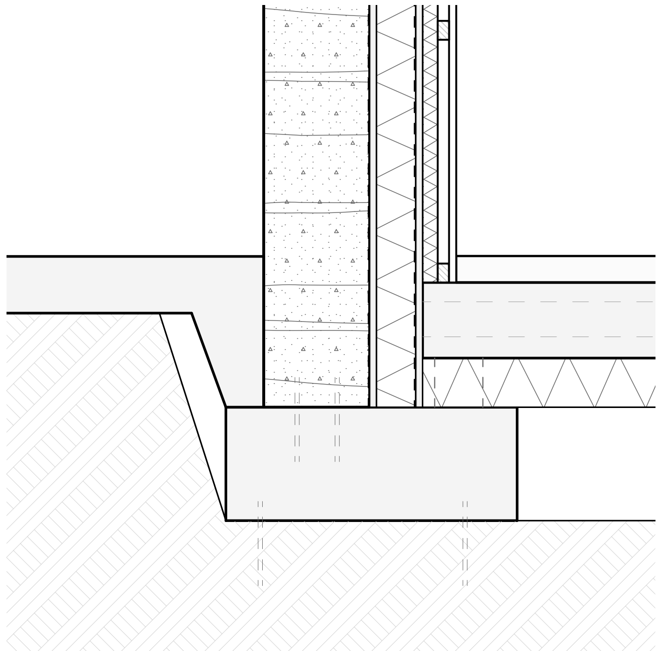
IMPLEMENTATION OF MORPHICS

The initial idea for an implementation of the MORPHICS technique in the project, was to create soft, almost velvet-like interior textures. This way, the texture palette would be extended to fit the purpose of creating a softer interior where needed throughout the building.

In principle, the MORPHICS technique is an ideal construction method in a remote location like this. The elements are lightweight, and transportation of the materials to manufacture on site is relatively easy due to the compactness of the needed materials.

The construction detail as can be seen on this page, could remain intact. Instead of the fibre board and timber finishing, the morphics panels can be installed. They offer a good insulation value, so the performance of the building physics would not be impacted.

Unfortunately, the implementation has remained in a more conceptual phase at this point of the project. The MORPHICS research has not been concluded due to the COVID-19 pandemic, which has also impacted its implementation in the design. Various form studies have been conducted to test out its implementation in the project, but none have yielded a satifying result that would compliment the project.



Construction detail of the foundation on rock soil.
1:20

The auditorium, as seen from outside.

AUDITORIUM

Before entering the building, one needs to descent down the auditorium steps. The auditorium is created in a circular shape, to soften the hardness of the rammed concrete. All exterior materials are relatively hard and cold in their texture and feel, to emphasise the outside environment one is still in.

The auditorium makes entering the building almost into a ritual. The view is being obscured the moment one walks into it. The only thing that is being expierienced at this point is thus the buildings materiality itself.

The lighting has been an important consideration for this circular shape. The sunlight that falls onto the texture, makes for an interesting shadow pattern, that either hardens the material expression by creating coarse shadows on the horizontal seams between the concrete layers, or it softens it, by spreading out a soft light over the rammed layers.

The central staircase, as seen from the communal patio on ground floor level.

CENTRAL STAIRCASE COMMUNAL AREA

The heart of the building is the central staircase that connects all the different movements within the building elegantly. It is bathed in daylight by the skylight above it. In it, the textures are again relatively hard and cold, as concrete and steel are the materials of choice. The vertical movement in the building is again made to be a certain kind of ritual.

In the impression on the left, one of two folding door entrances is shown that lead towards the communal space on ground floor. When these folding doors are open, the whole spaces opens up towards the communal patio.

Here, in the communal space, the feel and the expression of the material palette is still pretty cold and rough, mimicking the material palette as can be experienced on the outside of the building, but with a some softer materials introduced to emphasise that this space is indoors, and is meant to be shared with the residents and the community.

The central staircase, as seen from the first floor.

CENTRAL STAIRCASE KITCHEN

Once the central staircase leads one upstairs to the first floor, the material palette softens down a lot. When walking up the stairs, one is confronted with the beautiful view towards the West. Both the distant view and the view over the communal patio and garden can be experienced here. The space around the central staircase is still bathed in light by the skylight in the roof.

Directly adjacent to the central staircase are the kitchen and the dining area, which can be seen in the far end on the impression. This space is meant to be an important transitional space between what is private and what is communal. In theory the kitchen and dining area are reserved for the occupants themselves, but in reality this is the machine room for the self-sufficienct part of the house. Here, local produce is being prepared, and shared. Tourists and Ulva residents are being introduced to cooking local produce, and dinners can be hosted for larger parties. This is also why this space has the warmest and softest material palette,as it should be the space where the residents hang out the most, and feel most comfortable in their remote home.

The living space. The space is divided into two areas: a comfortable sitting area meant for socialising and watching television, and a sitting area that focusses on the view.

LIVING SPACE

The living space on the ground floor of the house is reachted by the secondary stair in the central staircase. This stair is more intimate and less light to emphasise the fact that it lead to the more private parts of the house.

The living space in somewhat harder in its material qualities, as it is more focussed on the enjoyment of the incredible view of the surroundings. It tries to mimick the surrounding material palette both in colour and in textural experience.

The engine block table is a reference to the Ulva saying that has already come up in the project:

"There is a saying that if anything mechanical stops working on Mull, it will end up on Ulva."

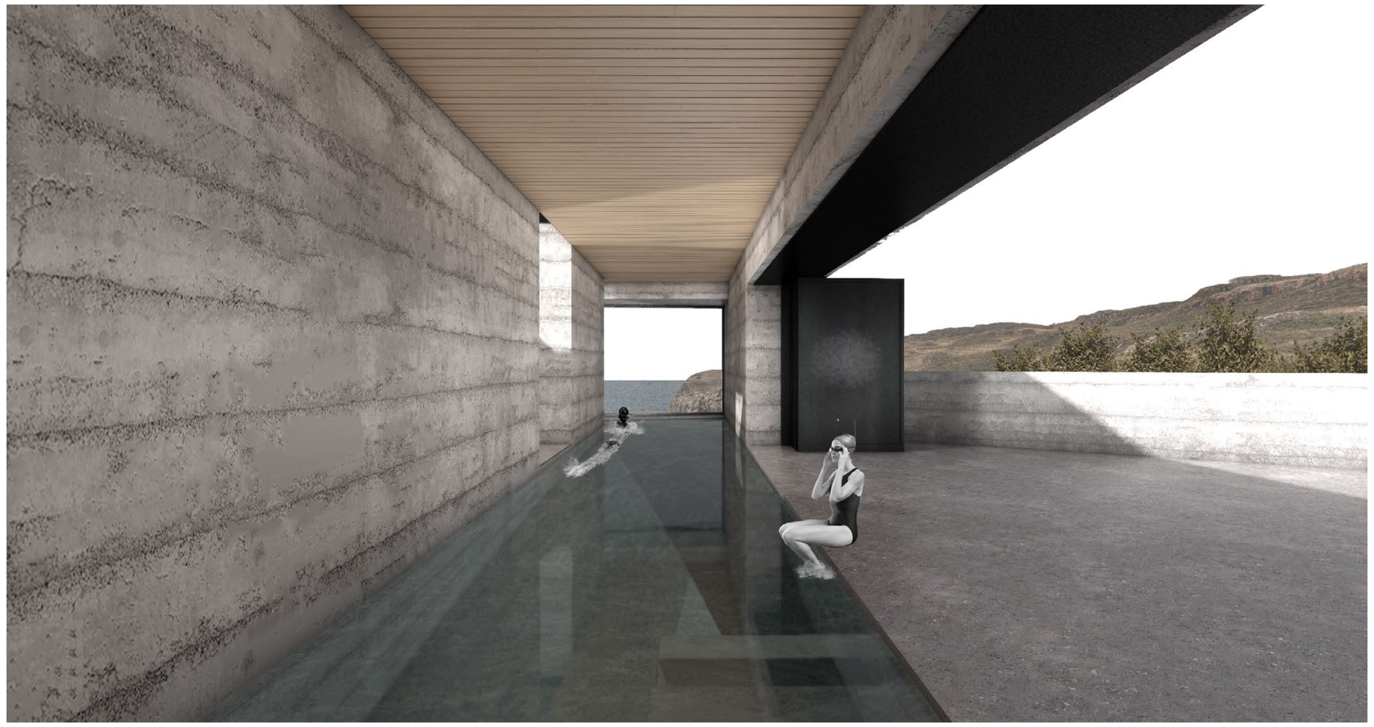
Though this may be the case, a second life can be given to everything. Broken mechanical things can be repared or repurposed into something useful or beautiful.

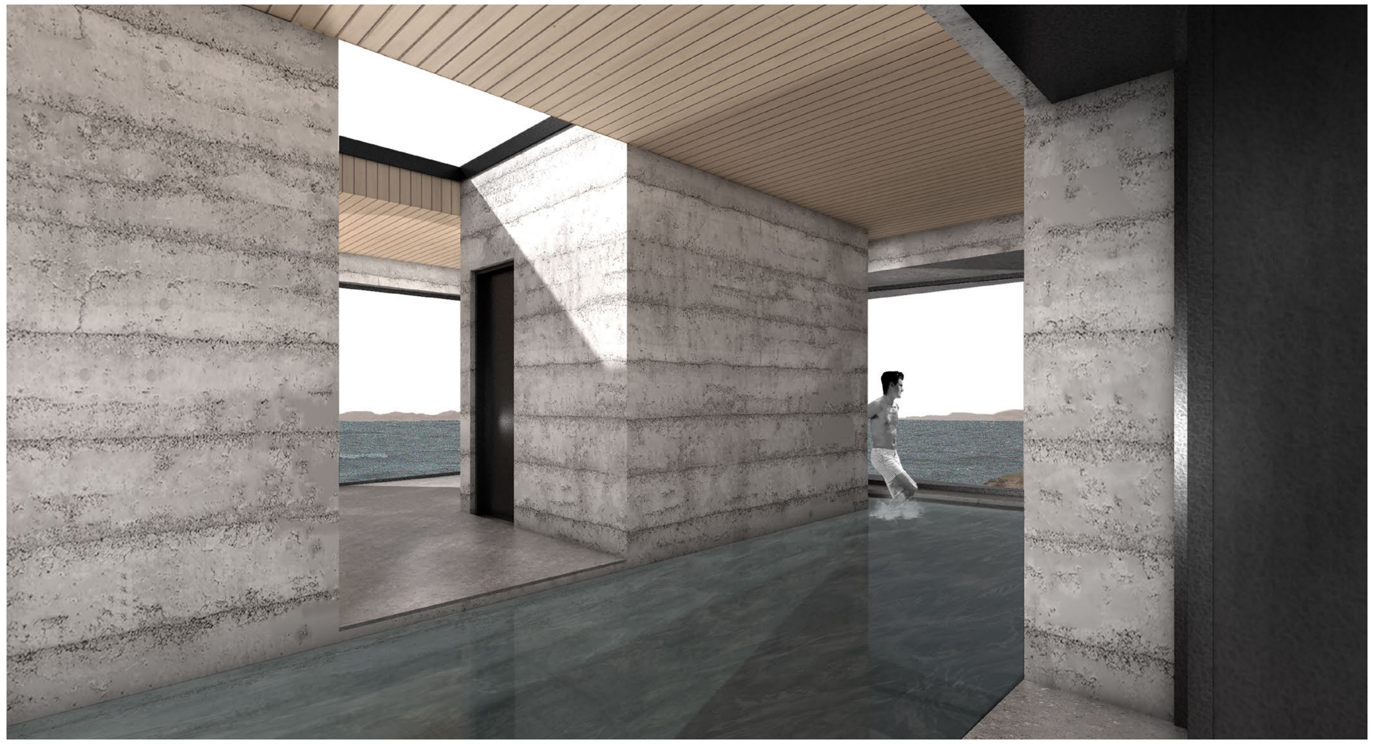
The other half of the living space is more intimate in its character, and offers a place for the whole occupancy of the house to come together and socialise or watch a movie.

The study and library. Offering a small space that can be utilised as an office during the day, and as a comfortable space to read in the evenings.

STUDY

Right next to the living space is the home office. It offers a space to work during the days, with a panoramic view over the ocean, and a place to read in the evenings with a skylight that offers a view on the moon and stars.





(1) The pool in the spa, as seen from the entrance. The folding doors are opened up, which opens up the space in its entirety towards the communal patio.
(2) The spa as seen from the communal patio. The middle volume offers a sauna with the amazing Western view, while also creating an elegant routing around it.

SPA

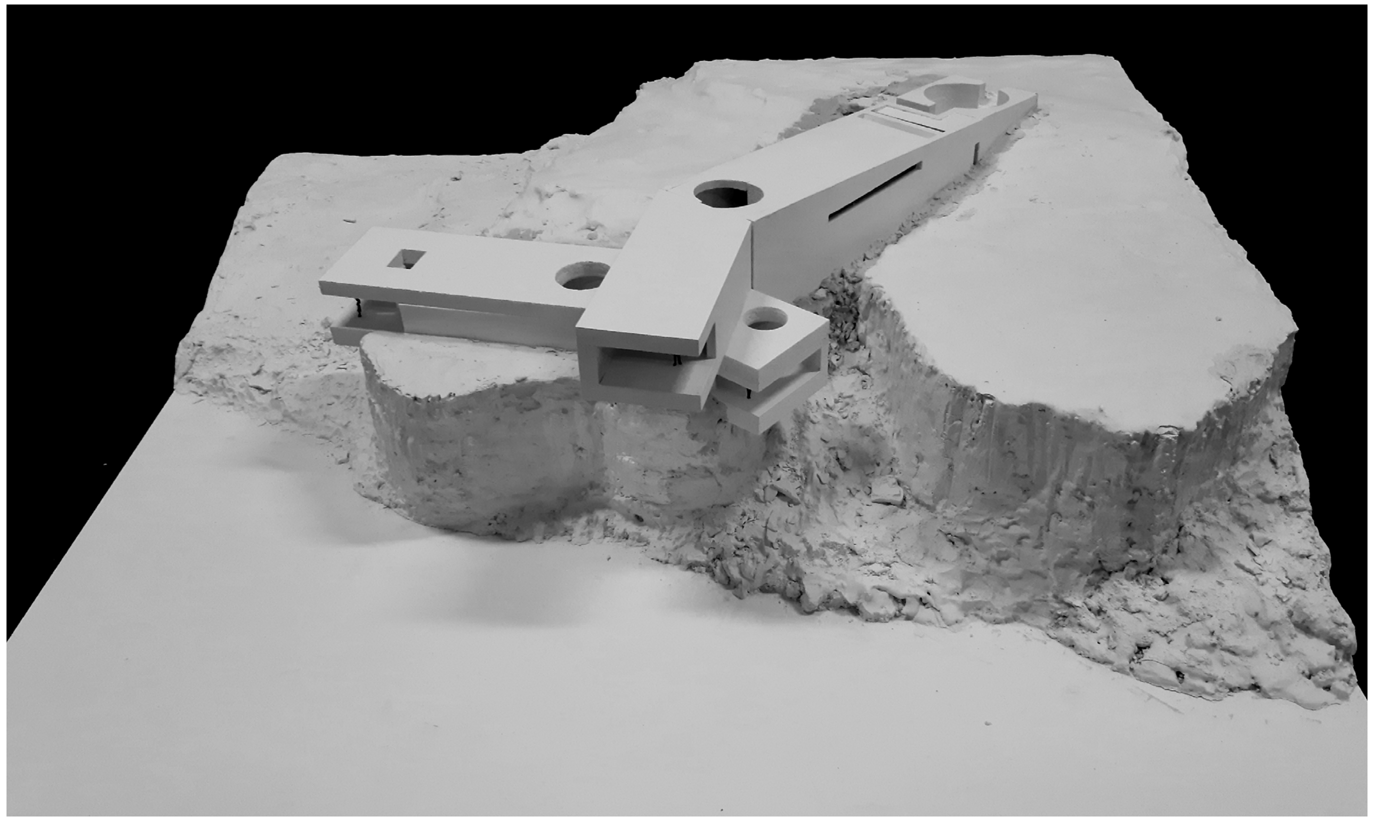
The material palette for the spa is kept to just three materials. The rammed concrete emphasises the length of the pool, and directs the swimmer towards the view at the end of it. The light coloured timber battens on the ceiling soften the impact of the otherwise hard and rough textures walls. Halfway along the pool, an opening is subtracted from the rammed concrete wall, which lets the light in from above, creating a playful interaction of the light on the walls.

The spa can be opened up towards the communal patio in its entirety by folding steel doors. Here, the choice was made to not make the panels transparant whatsoever. Once the folding doors are closed, the residents can use their spa is they desire, without having to worry about their privacy in any way. The dark coloured metal in these panels and their frames offer an interesting change of scenery to the otherwise matte, unreflective materials.

In the middle of the space of the spa, a heavy volume obscures the view towards the Southwest. In it, a sauna can be found, which capitalises on the breathtaking view over the open ocean. The sauna volume acts as an elegantly placed routing element in the room. One needs to move around it, walking along the panoramic windows that overlook, and hang over the ocean, before entering the pool.

WORKSHOP MODELS

A concrete model with a rammed concrete wall and the circular skylights.



Site model with the proposed Big House.

REMOTE ARCHITECTURE

In the end, a strong cohesive ensemble of buildings has been designed. The ensemble enables the residents to live in a remote location in a sustainable and self-sufficient manner. The ensemble, and the Big House in particular, offer the residents every possible way to make a living and provide for themselves in their everyday needs. The buildings do so in a manner that is respective towards, and in harmony with, the location. It creates a safe haven for its users, both inside and outside, and it allows its users to ejoy the location in an optimal way, as it embraces its remoteness in all respects.

On the same time, it has become a beacon for the community of Ulva. A place that can grow along with the population of Ulva, and one that helps them do just that. It is a place where the locals can come together, socialise, work, and plan the future of the island.

REMOTE ARCHITECTURE

ACKNOWLEDGEMENT

Firstly, I would like to express special grattitude towards my tutors Juliette Bekkering, Christina Nan, and Jan Schevers who have stimulated and motivated me over the past year to get the most out of this wonderful but challenging project.

I would like to thank my fellow students, as the first half of the project has been a collaborative effort.

I also want to express my gratitude towards Zeeshan Ahmed, who tutored us on the subject of digital fabrication, and helpen us design our own plastic extruder. With that, I would also like to thank everyone else involved with this project.

Lastly, I would like to shortly adress the COVID-19 situation that greatly impacted the project. The initial idea for the digital fabrication and the design project was to integrate them into a single multi-disciplinary project. Unfortunately, the two became two separate entities, which impacted the both of them somewhat negatively. The digital fabrication aspect of the project was unfortunately never finished.

It is important to realise that many of the initial goals that were set for this project were never met, such as the educational trips to visit iconic and/or relevant Big Houses throughout Europe, as a result of the pandemic. This lack of practical experiences, as well as the lack of much of the social interactions and educational dialogs between the participants of this studio has also taken its toll on some aspects of the project, and even slightly delayed it. It often seemed like some of the project was designed in an echo chamber, rather than in the collaborative, stimulating environemnt that it might have been if it weren't for the pandemic.

If the project were to have been a couple weeks longer, I would have focussed my attention on the implementation of MORPHICS into the project. The concept for its implementation was there, but the execution needed more work. Besides that, I would focus on finishing the interior spaces to a higher level of detail. I have spent a lot of time on designing the way natural light would enter and impact spaces, but few time on how artificial light could strengthen its atmosphere. Lastly, I would give my attention to designing custom furniture, fixtures and joinery for this project, as I feel it deserves that level of detailing.

Nevertheless, I feel that the project was brought to a satisfactory conclusion. I'm happy with the result, and I feel I have learned a lot over the past year. I would like to conclude by once again thanking all the people involved in the project, and also the people in my direct environment like my girlfriend, my family and my friends, who have always been eager to learn about the progress and the results of the project.

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