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Schwimmende Häuser
Floating Houses

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Abstract

Global warming is one of the most, if not the most, topics in our contemporary era. Its consequences significantly impact our daily life and have brought us to a breaking point. We should either plan forward or prepare for our extinction. Based on scientific research, this book introduces a fictional post-apocalyptic world in which the sea level has risen to the height of the high rises, humanity has lost a tremendous amount of land, and the goal is to survive and live on the water. Humanity has tens of thousands of years of experience living on land, but living permanently on the water, has its challenges. We are familiar with temporary living on the water, as ships are one of the oldest human inventions, which allowed us to travel on water and live a fleeting life on the water to a maximum couple of months. Learning from the past and solutions that nature found to survive the earth's drastic changes helps this project evolve and take shape. It proposes a two-story floating house, one above the water level and the second floor underwater. It makes the project a combination of a boathouse and a submarine. The house reacts to the water level based on the building's weight and calculates the right amount of water that needs to be in its ballast tank to hold the first floor always at the same height as the water. Sustainability and modularity are two essential aspects that play a massive role in the design of this project. In the final design phase, a Floating-Base took shape to provide the project's infrastructure needs and bring more comfort to the houses. It reinforces the project technically and delivers more quality for a better social life.

Abstrakt

Die globale Erwärmung ist eines der wichtigsten, wenn nicht sogar das wichtigste Thema unserer Zeit. Ihre Folgen haben erheblichen Einfluss auf unser tägliches Leben und haben uns an einen Wendepunkt gebracht. Wir sollten entweder vorausplanen oder uns auf unser Aussterben vorbereiten. Basierend auf wissenschaftlichen Forschungen stellt dieses Buch eine fiktive postapokalyptische Welt vor, in der der Meeresspiegel so hoch wie Hochhäuser gestiegen ist, die Menschheit enorme Landmengen verloren hat und das Ziel ist, auf dem Wasser zu überleben und zu leben. Die Menschheit hat Zehntausende von Jahren Erfahrung, an Land zu leben, aber dauerhaft auf dem Wasser zu leben, hat seine Herausforderungen. Wir sind mit dem vorübergehenden Leben auf dem Wasser vertraut, da Schiffe eine der ältesten menschlichen Erfindungen sind, die es uns ermöglichten, auf dem Wasser zu reisen und ein flüchtiges Leben auf dem Wasser bis zu einem Maximum von ein paar Monaten zu leben. Das Lernen aus der Vergangenheit und Lösungen, die die Natur gefunden hat, halfen diesem Projekt, sich weiterzuentwickeln und Gestalt anzunehmen. Es schlägt ein zweistöckiges schwimmendes Haus vor, eines über dem Wasserspiegel und das zweite Stockwerk unter Wasser. Es macht das Projekt eine Kombination aus einem Bootshaus und einem U-Boot. Das Haus reagiert auf den Wasserstand basierend auf dem Gebäudegewicht und berechnet die richtige Wassermenge, die in seinem Ballasttank vorhanden sein muss, um den ersten Stock immer auf der gleichen Höhe wie das Wasser zu halten. Nachhaltigkeit und Modularität sind zwei wesentliche Aspekte, die bei der Gestaltung des Projekts eine große Rolle spielen. In der abschließenden Planungsphase nahm eine Floating-Base Gestalt an, um den Infrastrukturbedarf des Projekts zu decken und den Häusern mehr Komfort zu bieten. Es stärkt das Projekt technisch und liefert mehr Qualität für ein besseres soziales Leben.

1 Introduction

This thesis, is about to present a possible solution for a fictional situation that is highly possible to become a reality soon, even if we start to control the case even today for a contemporary issue that is risking our life and habitat on this planet.The project takes place in the year 2087 when the water level has raised in a way that life on earth for Terrestrial animals is Barely possible, and we have to adapt ourselves to the new situation and find solutions for the challenges we will encounter because of global warming.

Figure 1.1: New york 23.Feb.2087AC. (Vray-Photoshop)

by the rise of sea level, many coastal cities around the world are already facing this challenge, with recent research finding that land currently home to 300 million people will flood at least once a year by 2050[30].
there are a couple of solutions in front of Humanity to choose from:

1. Stop global warming today.
   which is almost impossible as a part of this climate change is caused by constant and natural changes in our universe.

2. Build more dams.
   and hope the water level will stay the same as our barriers are going to last longer and protect us from the changes in Nature

3. Building on water.
   accepting the changes and adapting ourselves and our way of life to reality

The first two options are temporary solutions, if possible, and look like swimming against the stream, wasting a considerable amount of resources, and hoping our plan would work, staying optimistic. This thesis tries to present another vision, the third option, when our optimistic plans will not work, and we will be doomed to either accept the changes and adapt ourselves to them or vanish from this planet.
Of course, it would not be the most optimistic approach to plan for the time that we would not be able to bring changes, but also a realistic and sustainable vision through planning the future.
"The municipality wants to expand the concept of floating because it is multifunctional use of space for housing, and because the sustainable way is the way forward,"
says Nienke van Renssen, an Amsterdam city councillor from the GreenLeft party.

Based on this mindset, to see opportunity in every difficulty, the concept of the project started to take shape and became the subject of this Master's Thesis,**"Floating House."** The project's mission is to present a floating modular system that could extend itself from a single house to the creation of a district and even a city. This path would have many obstacles, as it is more or less a new subject. Moreover, this thesis scratches only the surface of this struggle by presenting a solution. A couple of great Architects like Kisho Kurokawa," Bjarke Ingels"(BIG Architects),also the Dutch offices like "Waterstudio","Framework Studio", "Barcode Architects", and a handful of other architects and Urban designers have already designed projects about living on water, as they also believed that would be the future of living on earth. One of the Obstacles we encounter in each design is the need for more knowledge and experience. Our knowledge from outer space is way more than our oceans, making it more challenging to forecast the issues we will face by living on the water. Our clock is ticking, and we need to use all the knowledge we have gathered to experience and learn more about living on the water. Algorithmic and parametric designs, and perhaps soon, Artificial Intelligent, would help us solve these issues, as floating Houses

should be intelligent creatures capable of updating themselves and adapting to new situations for an extended period.
"We now have the tech, the possibility to build on water," says Olthuis, who has designed 300 floating homes, offices, schools and health care centres. He added he and his colleagues *"don't see ourselves as architects, but as city doctors, and we see water as a medicine"*.

Figure 1.2: (Vray-Photoshop)

By losing land, we will lose our cozy houses and lots of resources we use for building products, producing food, and other human needs. for building products, producing food, and other human needs. Our primary sources of experimental living on the water are research and floating buildings designed in the Netherlands.

Figure 1.3: Schoonschip (Photograpy: SpaceMatters)

"We feel safer in a storm because we are floating,"
says Siti Boelen, a Dutch television producer who moved into Schoonschip two years ago. Strangely, building on the water is not a priority worldwide.

2 What Are Floating Houses?

Floating house is type of house which is constructed over a floating system which allows floating the whole structure over the water. Floating building is permanent structure which is fixed at one place and you can not navigate this from one place to another.

Figure 2.1: IJBURG, AMSTERDAM Photo credit: George Steinmetz [10]

This type of building can not move and it is tied up with another permanent structure. Floating building is environmental friendly structure because it does not create disturbance to the sea bed or the sore of the sea and all the wastes are perfectly placed to their destination.

A floating house can be constructed on any shoreline and is able to cope with rising seas or rain-induced floods by remaining atop the water's surface. Unlike houseboats, which can easily be unmoored and relocated, floating homes are fixed to the shore, often resting on steel poles, and are usually connected to the local sewer system and power grid. They are structurally similar to houses built on land, but instead of a basement, they have a concrete hull that acts as a counterweight, allowing them to remain stable in the water. In the Netherlands, they are often prefabricated, square-shaped, three-storey townhouses built offsite with conventional materials such as timber, steel and glass. For cities facing worsening floods and a shortage of land for housing, floating homes are one potential blueprint to expand urban housing in the age of climate change. Floating house is generally a modern type of technology which is very popular in recent times. In today's world, there are lack of free space to build a house or any type of structure because all the accessible free places are almost covered up.
To recover this problem, you need to think those problems in different ways. As the result, engineers have found an unique solution for this problem, which is floating houses. Floating houses are constructed on the wooden deck, all the other units of houses are installed after the deck is placed.[10]

2.1 Type of Floating Houses

There are generally two types of floating houses

1. Permanently Floating House
   It is a type of house which floats permanently on the water surface. It is a modern technique and it requires extra construction cost.

2. House that Floats During Flood
   Those houses which floats during flood time and when water goes out then it will on ground. This type of house is mainly found in Kerala.Those buildings are made of steel and the side walls are made of wood materials. Here we use steel pistons to avoid the flow of the whole building. In the time of flood the whole structure will go upward.

The main principle of floating house is to float the whole house. It is done by applying four steel tube support by which it can move upward or downward, it is applicable for those floating house which floats during flood time. The principle of other type floating house is it's floating all time over the water surface which is applicable for permanently floating house.[10] in this thesis the conceptual floating proposal is a mixture of type 1 and 2 of general floating houses, which this thesis explains more about it in details.

3 From Cave to Water

Earth's beginnings can be traced back 4.5 billion years, but human evolution only counts for a tiny speck of its history. The Prehistoric Period—or when there was human life before records documented human activity—roughly dates from 2.5 million years ago to 1,200 B.C. It is generally categorized into three archaeological periods:
the Stone Age, Bronze Age, and Iron Age.
From the invention of tools made for hunting to advances in food production and agriculture to early examples of art and religion, this enormous time span—ending roughly 3,200 years ago (dates vary upon region) was a period of great transformation.

Figure 3.1: Early human ancestors painting a bison inside a cave during the Paleolithic Age.Prisma/Universal Images Group/Getty Images [18]

The Stone Age

Divided into three periods: Paleolithic (or Old Stone Age), Mesolithic (or Middle Stone Age), and Neolithic (or New Stone Age), this era is marked by the use of tools by our early human ancestors (who evolved around 300,000 B.C.) and the eventual transformation from a culture of hunting and gathering to farming and food production. During this era, early humans shared the planet with a number of now-extinct hominin relatives, including Neanderthals and Denisovans.
In the Paleolithic period (roughly 2.5 million years ago to 10,000 B.C.)[18]

3.1 Conquering the plains

Early humans lived in caves or simple huts or tepees and were hunters and gatherers. **The end of this period marked the end of the last Ice Age**, which resulted in the extinction of many large mammals and **rising sea levels and climate change that eventually caused man to migrate.** During the Mesolithic period (about 10,000 B.C. to 8,000 B.C.), humans used small stone tools, now also polished and sometimes crafted with points and attached to antlers, bone or wood to serve as spears and arrows. They often lived nomadically in camps near rivers and other bodies of water. Agriculture was introduced during this time, which led to more permanent settlements in villages.
Finally, during the Neolithic period (roughly **8,000 B.C. to 3,000 B.C.**), ancient humans switched from hunter/gatherer mode to agriculture and food production. They domesticated animals and cultivated cereal grains. They used polished hand axes, adzes for ploughing and tilling the land and **started to settle in the plains**. Advancements were made not only in tools but also in farming, home construction and art, including pottery, sewing and weaving.[18]

3.2 Floating on water

The oldest boat discovered so far is the 3 meter long Pesse canoe constructed around 8,000 B.C.; but other craft existed even earlier. A rock carving in Azerbaijan dating from 10,000 BCE shows a reed boat manned by about 20 paddlers. In Northern Europe, some argue that hide boats (kayaks) were used as early as 9,500 BCE. However, the very first sea-worthy boats were most probably built long before that; not by Man but by Archaic humans (also called Hominins), species in our evolutionary line. But which species and when remained unanswered questions until very recently. In the 1990s proof of archaic seafaring was finally discovered: stone tools dated to 800 Kya and typical of Erectus were found on the island of Flores. Reaching Flores from Java entails crossing several channels totalling over 60 km. In order to transport groups large enough to achieve permanent settlement, large rafts like the one shown below were probably used. Later, in 1996, the First Mariners Project replicated these crossings.[14]

Figure 3.2: Strait islanders on a bamboo raft, 1906
Encyclopedia of New Zeland[14]

Evidence of the nature of these early boats comes from unearthed remains, petroglyphs and other drawings - starting around 10,000 BCE (12 Kya). To this we can add boats that are in use today but could have been constructed with stone-age tools. existed before metal tools were developped and cities arose. More specifically, before wood planks allowed the construction of large ships for war and commerce around 3,000B.C.[14]

As surreal as it sounds, it seems that Nature is playing the same game with us again; our planet is getting warmer, the sea levels are going to rise, and we have to move out of our caves and refuge to a new unknown vicinity. Either we must leave earth or find another solution to survive on this planet. Colonizing on other planets, if even possible, is far fetch based on our technology and the knowledge and control that human has over their biology and the energies in this universe. The other option would be leaving on water, it seems impossible as we have never accommodated in large numbers for a long time on a fluid matter, and we have no experience with the result of this decision, but neither had the ancient humans who left their caves to live on land. The difference is that we have new technologies which help us overcome these challenges, almost like the tools ancient humans used to survive on land we have computers that can calculate situations we have never experienced before by feeding them the correct pieces of information. These machines make what was earlier almost impossible to become a reality.

4 Sea levels will rise

Sea level rise is going to be an ongoing problem for centuries to come,in March 2021, the UN's World Meteorological Organization (WMO) warned that oceans were under threat like never before and emphasized the increasing risk of rising sea levels.Around 40% of the global population live within 100 kilometers of the coast.WMO Secretary-General Professor Petteri Taalas said there was an "urgent need" to protect communities from coastal hazards, such as waves, storm surge and sea level rise via multi-hazard warning systems and forecasting.[32] we will have to keep on adapting over and over again. It's going to be a whole new expensive lifestyle, costing trillions of dollars. "Sea level has a very long memory, so even if we start cooling temperatures, the seas will continue to rise. It's a bit like trying to turn the Titanic around, rather than a speedboat."

Figure 4.1: A potential scenario of future sea level rise in South Beach, Miami, Florida, with a global temperature rise of 2C. Photograph: Nickolay Lamm/Courtesy Climate Central[13]

Researchers used a computer model that simulates sea level rise in response to various emissions levels, looking both at historical emissions since 1750 and also what the emissions scenario would be from 2015 to 2030 if countries met their Paris Agreement obligations. The results reveal the daunting prospect of a near-endless advance of the seas, forcing countries to invest huge resources in defending key infrastructure or ceding certain areas to the tides. Many coastal cities around the world are already facing this challenge, with recent research finding that land currently home to 300 million people will flood at least once a year by 2050 unless carbon emissions are drastically slashed. As the world heats up, ocean water is expanding while land-based glaciers and the two great polar ice caps are melting away, causing the oceans to swell. According to the UN's climate science panel, the global sea level rise could reach as much as 1.1 meters by the end of the century if emissions aren't curbed. Clark pointed out the real situation could be even worse if the melting of the Antarctic turns out to be on the dire end of the spectrum of uncertainty.[13]

Figure 4.2: Maps of Lost Southern Florida Coastal Land as a Function of Increasing Levels of Global Sea Level Rise.[19]

"People are going to become less inclined to live by the coast and there are going to be sea level rise refugees," Clark said. "More severe cuts in emissions are certainly going to be required, but the current Paris pledges aren't enough to prevent the seas from rising for a long, long time."

Figure 4.3: The IPCC says sea levels could rise around

30-60 cm by 2100 even if greenhouse gas emissions are sharply reduced and global warming is limited to well below 2°C[11]

4.1 Global Warming

This graph illustrates the change in global surface temperature relative to 1951-1980 average temperatures, with the year 2020 tying with 2016 for hottest on record (Source: NASA's Goddard Institute for Space Studies). Learn more about global surface temperature here. Credit: NASA/JPL-Caltech Global warming is the long-term heating of Earth's surface observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere. This term is not interchangeable with the term "climate change."

Figure 4.4: hange in global surface temperature[12]

Since the pre-industrial period, human activities are estimated to have increased Earth's global average temperature by about 1 degree Celsius (1.8 degrees Fahrenheit), a number that is currently increasing by more than 0.2 degrees Celsius (0.36 degrees Fahrenheit) per decade. The current warming trend is unequivocally the result of human activity since the 1950s and is proceeding at an unprecedented rate over millennia.from the Neolithic era or New Stone Age. From pit huts constructed largely of mammoth bones to artificial islands known as crannogs, we were building structures to protect us from the elements, predators, and other people.[26]

4.2 Climate Change

Climate change is a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates. These changes have a broad range of observed effects that are synonymous with the term.
Changes observed in Earth's climate since the mid-20th century are driven by human activities, particularly fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere, raising Earth's average surface temperature. Natural processes, which have been overwhelmed by human activities, can also contribute to climate change, including internal variability (e.g., cyclical ocean patterns like El Niño, La Niña and the Pacific Decadal Oscillation) and external forcings (e.g., volcanic activity, changes in the Sun's energy output, variations in Earth's orbit).

Figure 4.5: 2019 Rising Waters Florida$_{M}iami_{w}aterfront$

Scientists use observations from the ground, air, and space, along with computer models, to monitor and study past, present, and future climate change. Climate data records provide evidence of climate change key indicators, such as global land and ocean temperature increases; rising sea levels; ice loss at Earth's poles and in mountain glaciers; frequency and severity changes in extreme weather such as hurricanes, heatwaves, wildfires, droughts, floods, and precipitation; and cloud and vegetation cover changes.[26]

4.3 Causes of Climate Change

Scientists attribute the global warming trend observed since the mid-20th century to the human expansion of the "greenhouse effect" warming that results when the atmosphere traps heat radiating from Earth toward space. Life on Earth depends on energy coming from the Sun. About half the light energy reaching Earth's atmosphere passes through the air and clouds to the surface, where it is absorbed and radiated in the form of infrared heat. About 90% of this heat is then absorbed by greenhouse gases and re-radiated, slowing heat loss to space.
Human Activity Is the Cause of Increased Greenhouse Gas Concentrations Over the last century, burning of fossil fuels like coal and oil has increased the concentration of atmospheric carbon dioxide (CO2). This increase happens because the coal or oil burning process combines carbon with oxygen in the air to make CO2. To a lesser extent, clearing of land for agriculture, industry, and other human activities has increased concentrations of greenhouse gases. How do we know what greenhouse gas and temperature levels were in the distant past? The industrial activities that our modern civilization depends upon have raised atmospheric carbon dioxide levels by nearly 50% since 1750. This increase is due to human activities because scientists can see a distinctive isotopic fingerprint in the atmosphere. In its Sixth Assessment Report, the Intergovernmental Panel on Climate Change, composed of scientific experts from countries all over the world, concluded that it is unequivocal that the increase of CO2, methane, and nitrous oxide in the atmosphere over the industrial era is the result of human activities and that human influence is the principal driver of many changes observed across the atmosphere, ocean, cryosphere and biosphere.[27]

4.4 Human Activity

The rate of change since the mid-20th century is unprecedented over millennia. Earth's climate has changed throughout history. Just in the last 800,000 years, there have been eight cycles of ice ages and warmer periods, with the end of the last ice age about 11,700 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives. The current warming trend is different because it is clearly the result of human activities since the mid-1800s, and is proceeding at a rate not seen over many recent millennia.1 It is undeniable that human activities have produced the atmospheric gases that have trapped more of the Sun's energy in the Earth system. This extra energy has warmed the atmosphere, ocean, and land, and widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred. Do scientists agree on climate change? Earth-orbiting satellites and new technologies have helped scientists see the big picture, collecting many different types of information about our planet and its climate all over the world. These data, collected over many years, reveal the signs and patterns of a changing climate. Scientists demonstrated the heat-trapping nature of carbon dioxide and other gases in the mid-19th century.2 Many of the science instruments NASA uses to study our climate focus on how these gases affect the movement of infrared radiation through the atmosphere. From the measured impacts of increases in these gases, there is no question that increased greenhouse gas levels warm Earth in response.

Ice cores drawn from Greenland, Antarctica, and tropical mountain glaciers show that Earth's climate responds to changes in greenhouse gas levels. Ancient evidence can also be found in tree rings, ocean sediments, coral reefs, and layers of sedimentary rocks. This ancient, or paleoclimate, evidence reveals that current warming is occurring roughly 10 times faster than the average rate of warming after an ice age. Carbon dioxide from human activities is increasing about 250 times faster than it did from natural sources after the last Ice Age.[28]

"We know more about the surface of the Moon and about Mars than we do about [the deep sea floor], despite the fact that we have yet to extract a gram of food, a breath of oxygen or a drop of water from those bodies."

— Paul Snelgrove.

5 Ancient Architecture and the Human Need to Construct

Humans have been building homes and structures for centuries. Ancient buildings give us hints into cultural and religious motives of those who built before us. So, is it in our nature to construct? There's often a distinction drawn between 'natural' and 'man-made'. A colony of beavers builds a dam to create a still pond in which they can construct a secure lodge to live in. Humans build a dam – admittedly on a far larger scale – and produce reservoirs to provide drinking water for their own settlements. One is generally considered to be natural behaviour while the other will be described as man-made – as if human beings are no longer part of the natural world. But is it in our own nature to construct things? Are humans built to build and if so, where will this take us in the future? Ancient architecture and a brief history of buildings We've all heard of so-called cavemen and there's certainly plenty of evidence that early humans made use of naturally formed shelters such as caves. We don't know exactly when humans first started constructing their own shelters because the simplest structures – tents, bivouacs and simple huts made of sticks and hides – don't leave a trace. What we know is pretty much based on supposition and observing the way nomadic people still live in remote parts of the world. There is, however, plenty of evidence of building, and many preserved structures remain from the Neolithic era or New Stone Age. From pit huts constructed largely of mammoth bones to artificial islands known as crannogs, we were building structures to protect us from the elements, predators, and other people.[34]

5.1 Cities and the 'built environment

One common thread in the development of permanent structures was the switch from a hunter-gatherer to an agrarian or agricultural lifestyle. As people quite literally put down roots, they started building more ambitious structures and gathering in greater numbers. This gave rise to the first cities and what would later be termed the built environment. Bringing large numbers of human beings together inevitably creates problems, from social issues such as violence to the possibilities of epidemics taking hold. A built environment with some thought behind it can also be beneficial to health and social cohesion, however. Hippodamus of Miletus used grid plans to develop Greek cities in the 5th Century BC and is known as the 'father of urban planning.' Roman cities had public bathhouses and aqueducts bringing in fresh water that was piped into public drinking fountains. Throughout history, there have always been innovators working to make communities better and more efficient. In our more recent history, as infrastructure has grown, there have been those who have worked and campaigned for our towns and cities to work for the benefit of all. Mindy Fullilove, who is currently a professor of Urban Policy and Health at The New School in New York, has proposed the 'whole city concept'. Fullilove discusses the concept of facing disasters in poor communities and how the inequality amongst neighborhoods affects an entire society.[34]

5.2 Oldest buildings around the world

The construction of the past has shaped and molded the world we live in today. From the pyramids to the hanging gardens and Buckingham Palace to the ancient city of Athens, old buildings impact how we look at construction and how contractors build structures today. Taking a deeper dive into the oldest buildings and structures around the world gives us a hint at what our ancestors valued, how they maintained their cultures and what life was like for them thousands of years ago. Let's explore some of the oldest buildings around the world. How were they created? What was their use? What construction processes did these structures need? And more importantly, are these buildings still intact today?

- **Göbekli Tepe**
  Göbekli Tepe is an archaeological site of a temple in Southeastern Turkey and has been dated back to 9500 - 8000 BCE. This date was discovered by carbon dating old tools found during excavations. This building is, in fact, the oldest structure on earth that we have found to date. It is even older than the Egyptian pyramids and even Stonehenge. The buildings that makeup Göbekli Tepe are large circular structures supported by stone pillars. The interesting thing about this is that the pillars are decorated with carvings and drawings of animals such as oxe, lions, scorpions and vultures. Some of the pillars are blank, while others feature these animals, winding and covering all sides. These carvings provide an insight into how the people lived at the time. Archaeologists have concluded that this area, long before it was farmed into a relatively flat and open area, would have been a paradise of sorts. The land would have been full of grazing animals, birds, butterflies and life. There is no definite answer about how much manpower was used to build it. Since there was a lack of equipment back then, it's right to assume that larger numbers and a generous amount of manpower would be needed to haul rock and move the stone from quarries up into this area.[16]

Figure 5.1: Göbekli Teppe the first temple in History[16]

- **Cairn of Barnenez**
  The Cairn of Barnenez is a monument that can be found in Northern France. This is the second oldest structure in the world, dated all the way back to 4800 BCE. This is the largest megalithic mausoleum found to date. "Megalithic mausoleums" are buildings that house tombs and burial chambers. They are often built underground and were looked at as a passageway for the dead to reach the afterlife.

Figure 5.2: Cairn of Barnenez[16]

  Construction of the Cairn of Barnenez is said to have taken place in 2 phases. The first phase began in 4850 BCE while the second phase began in 4200 BCE. These two phases of construction can be seen in physical construction differences between certain tombs. Dolerite - which is a fine-grained rock - was used to construct the stone houses within the first phase. Granite - which is a coarse-grained material - was used in the second phase of construction in order to cool and solidify the underground passages.[16]

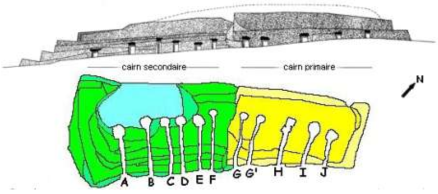


Figure 5.3: Entrances in Plan and section[16]

- **Tumulus of Bougon**
  The Tumulus of Bougon is the 3rd oldest building in the world and is also located in France. This building is actually 5 different

tumulus' located on one site. Construction of Tumulus of Bougon was done at various times during a period of 1200 years from 4700 to 3500 BCE. To construct the 5 parts of the Tumulus, dry stone walling was used. Oddly enough, a beehive roof structure was also created using natural resources such as grass, and of course, more stone. To reinforce the structure and prevent collapse, drystone walling was implemented around the outside of the burial sites. Much like the Cairn of Barnenez, not much is found about labor or equipment used, so once again it can be assumed that labor was intensive. Due to the time period, hand labor and basic tools would have been used in construction. The extremely long time period hints that this structure was built upon and added to as needed.[16]

Figure 5.4: Tumulus of Bougon[16]

- **Uruk**
  Another one of the world's oldest structures is Uruk. Uruk actually isn't just a single building but an ancient city. It is believed to be the first city ever created. It was made up of many temples and other buildings in Iraq and represents a turning point in the history of civilization. Constructed in 4000 BCE, Uruk was home to about 40,000 people. So far, archaeologists have been able to identify 20 temples, 1 room, 2 normal halls, 1 great hall, and 4 buildings for bathing and other necessities in the remains. The various buildings within the city or Uruk allowed the 40,000 residents to live comfortably, even allowing for up to 80,000 inhabitants at various times.[16]

Figure 5.5: The Great City of Uruk Became Sumerian Powerhouse of Technology, Architecture and Culture[2]

- **Knap of Howar**
  The Knap of Howar is a stone-built farmstead that may be the oldest preserved stone house in all of Europe. It is located in Scotland and dates back to 3700 BCE. The building consists of two stone-wall buildings overlooking the sea. The first stone house is said to be living quarters, whereas the second stone house is deemed as a workshop. Both would have been lit by fires to stay warm and are equipped with holes in the roof to let out the smoke.

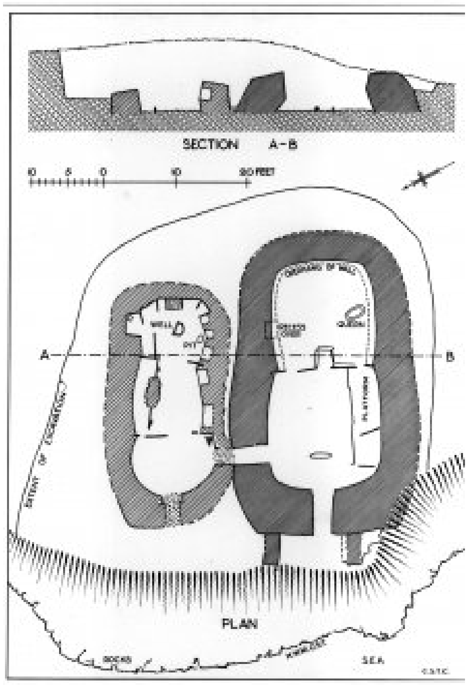


Figure 5.5: Plan and Section[16]

These stone homes were used for farming purposes. It’s believed that the inhabitants kept cattle, sheep and pigs. They also cultivated their own grains. The proximity to the sea meant that fishing and gathering shellfish would have been part of their food source as well.[16]

Figure 5.6: Knap of Howar[16]

5.3 Bigger, Taller, Better

We've already mentioned some of the earliest habitation types and villages. These were built primarily with practical applications in mind, and features such as the Skara Brae drainage system demonstrate some surprisingly sophisticated solutions to practical problems. Not every structure we build has an obvious function, however, and some go beyond mere necessity to have a wider social, cultural or religious meaning. We're still not sure exactly what Stonehenge was intended for, but even today, it's a massively imposing and impressive structure. It was built in stages, with the first wooden 'totem-pole-like' posts in the immediate area erected in the Mesolithic period, between 8500 and 7000 BC. The familiar sarsen and blue stone henge went up in about 2500 BC and, whatever the exact function of the complex, there's little doubting that it would have declared the power and importance of its builders and custodians. Similarly, the Great Pyramid of Giza and other pyramids were built to reflect the glory of the pharaohs whose bodies they housed. According to the story, the Tower of Babel saw mankind punished for trying to build a tower capable of reaching the heavens. Some modern scholars believe it may refer to known historical structures, such as the Great Ziggurat of Ur. From the Taj Mahal to the Eiffel Tower to The Shard in London, grand structures have always captured the human imagination, and modern skyscrapers now dwarf their predecessors. The world's current tallest building is the Burj Khalifa in Dubai. Standing at 828 meters – considerably more than double the height of one-time champion, the Empire State Building. [34]

5.4 The history of house building

From cavemen to skyscrapers, houses have developed over the ages parallel to experiences human rec ivied during thousands of years of building and architecture on land.

5.4.1 Prehistoric

When men and women first emerged from caves and tried to build a home, early attempts were little more than crude screens of branches and twigs that gradually became walls of turf or stone.[36]

Figure 5.7: Prehistoric Building Typology[17]

5.4.2 Romans

The biggest change to these early methods came with the Roman invasion in 43AD. The Romans brought concrete construction to Britain and jointing mortar that was so strong that walls became an almost monolithic mass. When the Romans quit Britain in 430AD, home building techniques regressed significantly. As a result, during the Iron Age houses were only up to 10.5 m in diameter, and were built using posts driven into the earth and the gaps filled by wattle daubed with clay. Only where timber was in greater supply were split tree trunks or planks used.[36]

Figure 5.8: A cut-away image of a typical Roman domus.[15]

5.4.3 Medieval

In 1135, there was a great fire in London. To stop this happening again, the Ordnance of 1212 barred thatched roofs being used on new homes in London. As a result, clay tile-making became common across eastern and southern England by the thirteenth century. At the same time, plastering also came into general use. Many early medieval cities, certainly London, utilized rag stone from quarries in Kent or Surrey. Chalk and flint, often produced by digging out old Roman foundations, also provided popular building products. Building regulations were introduced from around 1200. Early rules included stone party walls of at least three feet, but this was often flouted, leading to many accidents. As a result, stone became less commonly used for walls.[36]

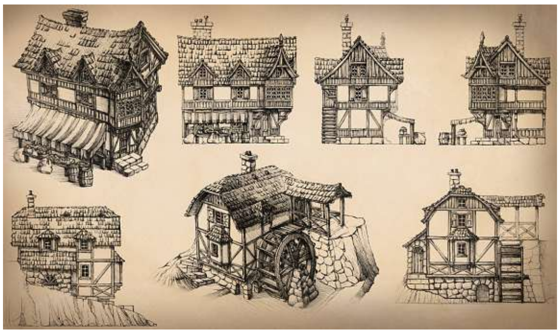


Figure 5.9: Medieval Buildings by Grimdreamart

5.4.4 Renaissance

Buildings were still being built entirely from timber in the late sixteenth century, with brick only really used for chimneys and hearths. But as the farmers who had previously acted as part-time home builders were replaced by brick-makers and master builders, using bricks to build homes became more common. By the late 1500s, windows also started to be used. But it wasn't until the Baroque Age that we saw a significant increase in the use of them. This was thanks to key technological advances in the glassmaking industry being introduced at the time.[36]

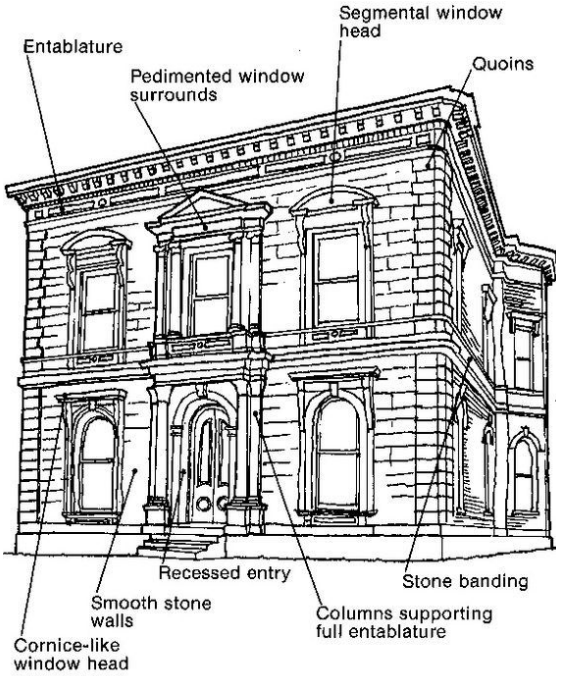


Figure 5.10: Renaissance Architecture

5.4.5 Gothic

The first terraced housing had been introduced in the late seventeenth century and the first apartments - known then as garden flats - emerged in the 1860s, just before house building entered a boom period. Between 1870 and the outbreak of World War One in 1914, nearly five million homes were built in the UK. The development of the sash window in the late seventeenth century further fuelled this trend. Windows became even more wide-spread after improvements in the production of sheet glass in the early 1830s, and metal slowly began to replace wood in the construction of window frames.[36]

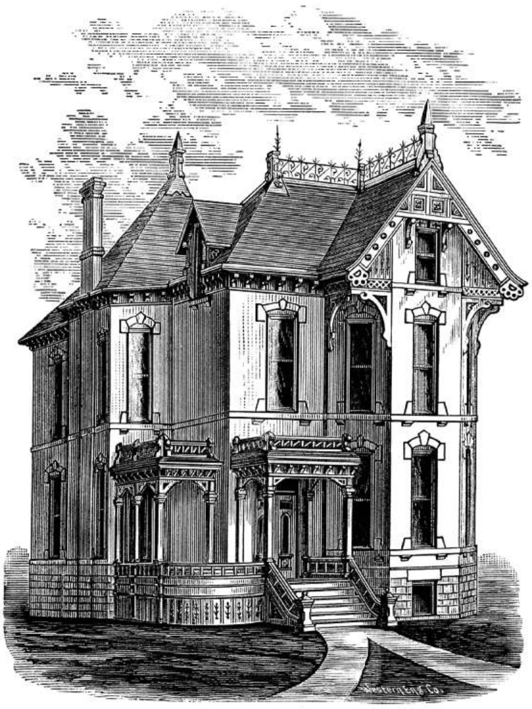


Figure 5.11: Gothic House

5.4.6 1930-1950

In the 1930s, house building flourished, offering insurance against potential defects in new homes, responding to fears dating back nearly a century.

Figure 5.12: A row of prefab housing in Camberley Road Hough End Estate Manchester (March 1954)[25]

In the decade after World War Two, swathes of new homes were needed across bomb-torn Britain, and the pre-fab was born. Around 70,000 bungalows were built under the Temporary Housing Program over the ensuing decade using aluminum alloys.[36]

Figure 5.13: Detroit Houses in the 1950s Photograph courtesy of Steve Wilke[9]

5.4.7 1950-1970

The 1950s brought a surge in the building of the modern style of blocks of flats, which began in 1951 with the construction of The Lawn in Harlow, Essex, now a Grade II listed building. Building regulations were relaxed in 1954, fuelling the rise in home building. Between 300,000 and 400,000 homes were built every year during this decade, mostly featuring new amenities, such as fixed baths, running water and lifts in apartment blocks.[36]

Figure 5.14: Typical Towerblocks (1960)

5.4.8 1970-1990

As the house building industry recovered from the recession in the 1970s, national companies building homes across the UK began to emerge, setting a pattern that survived the 1990s recession and still remains today. This house building boom lasted until the 1970s, when the new towns of Basildon, Harlow, Milton Keynes and Peterborough sprang up - many featuring houses built using timber frames.[36]

Figure 5.15: La Muralla Roja (The Red Wall$_1$973)*RicardoBofill*

5.4.9 Modrn Day

Today, many of the new homes at the cutting edge of house building feature a range of environmentally friendly features as the industry pushes towards the zero carbon home. From natural ventilation to passive solar gain, water harvesting to mechanical ventilation and heat recovery, cellular clay blocks and ground source heat pumps, the modern new house bears little relation to its forebears other than the most important of all: providing a home.[36]

Figure 5.16: Lighthouse Zero Energy Home(UK)[33]

6 Case Study

There are floating architectures constructed all over the world. Couple of them are milestone floating architectures

6.1 Drijvend Paviljoen (Floating Pavilion)

The Floating Pavilion is widely recognized as Rotterdam's pioneering project for building on water. PDA designed the iconic building and oversaw the construction from start to end. It took less than a year.

Figure 6.1: Floating pavilion, Rijnhaven, Rotterdam[7]

it plays an important role both as a showcase of building on water and as an information and reception area. The iconic building allows the city to give space to experiments and knowledge exchange on floating constructions. And this for a good reason: the surrounding region has more than 24,000 ha. that is not protected against high tides. In addition, an area of over 1,600 ha . – formerly docks and harbour areas – are becoming available for new developments. Two key characteristics of building on water are the **low weight of the construction** and the **potentially short building time**. The three domes of the Floating Pavilion have been made based on a single-layer lattice construction in steel overlaid with a transparent, isolating skin with cushions made from EFTE, a superlight material originally conceived for space applications. Using prefabricated modules, the onsite construction took less than one and a half week.

Figure 6.2: Floating pavilion, Rijnhaven, Rotterdam[7]

The Pavilion's exterior and interior have a stylish finish using robust, natural materials. The building contains sustainable solutions for energy and climate management, and for air and wastewater treatment – all state-of-the-art at the time of construction. Heating and cooling is done through solar energy, surface water, and natural ventilation. There are separate climate zones with their own heating and cooling requirements, adding to the efficient energy use. The Floating Pavilion is largely self-sustaining and only needs exterior connections to supply electricity and drinking water. It can therefore easily be uncoupled and moved to another location.[7]

6.2 Exbury Egg / PAD studio + SPUD Group + Stephen Turner

The project is led by art, architecture and education consultants, Space Placemaking and Urban Design (SPUD Group). SPUD project manager, Phil Smith explains: "Everything about this project looks to the value of our environment and sustainability; from the design and build of the Egg, to working with Stephen Turner in raising awareness of environmental change, to creating a cross curriculum education programme for schools and colleges." Created and designed by PAD studio and Stephen Turner, the Egg was inspired by the nesting seabirds on the shore. It was built locally, by boat-builder Paul Baker, as a cold moulded reclaimed cedar -sheathed structure approximately 6 metres long and 2.8 metres in diameter, whose aging will be tracked by the artist. Local Douglas Fir has been used for the supporting ribs and internal framing; continuing the age-old tradition of timber marine construction on the Beaulieu River.

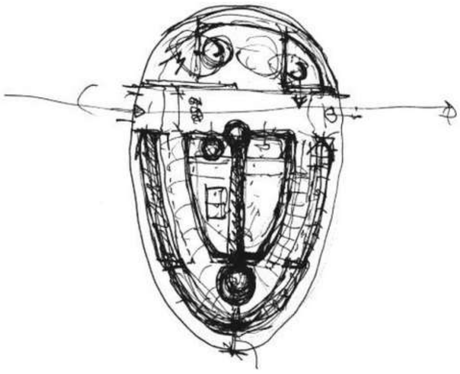


Figure 6.3: Exbury Egg Architects sketches[3]

Wendy Perring, the project architect, explains: *'It was our intent to create a minimal impact live/work structure, using materials with low embodied energy sourced within a twenty mile radius, and put together by a team of local craftsmen using centuries old techniques. We want to test the minimum someone needs to live quite comfortably, and how we can minimise the impact on the environment."*

Figure 6.4: Exbury Egg on water[3]

Inspired by the estuary and its ecology, Stephen Turner will develop the Egg into one of his artworks through the course of the residency; an on-going record of his work will be available for the public to see at Exbury Gardens and on the project website. At the end of the project, the Egg will become part of a sculptural installation of the artist's work and shown in galleries across the country. Stephen explains his plans: *"My contribution to the design concept of the structure was its symbolic egg form, that will decay and change during my occupation; My idea is to show that nothing is forever and that understanding and welcoming such change should be part of our sustainable relationship with the rest of nature. I wanted to investigate the landscape at a key moment when climate change is already creating new shorelines and habitats. Established salt marsh is being eroded by a combination of rising sea levels and falling landmass and the entire littoral environment is in a state of flux. The implications for wildlife and flora as well as people are challenging and raise awareness of a particularly 21st century sort of tension."*[3]

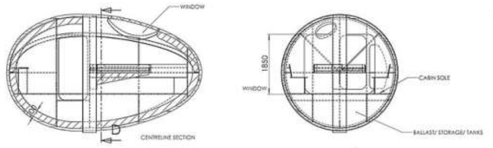


Figure 6.5: Sections [3]

6.3 wa sauna / goCstudio

Wa sauna engages the ideas of journey and discovery; creating a unique experience and refuge on the water that offers a different perspective on the landscape. Boaters and kayakers can venture out and tie off to the surrounding deck, allowing for the sauna tradition to take place on Seattle's lakes.

Figure 6.6: wa sauna[5]

Maneuvering a 14' high, 4,500lb structure from the warehouse to the public boat ramp and into the water was a challenging process. Towed on 6 steel casters with a 1980 VW Vanagon, we slowly crept along at dawn making the 8 block trip to the boat ramp in just under 3 hours. The contrast of steel casters on rough gravel and pavement to the feeling of this structure gently floating was the most exciting moment of the build process.[5]

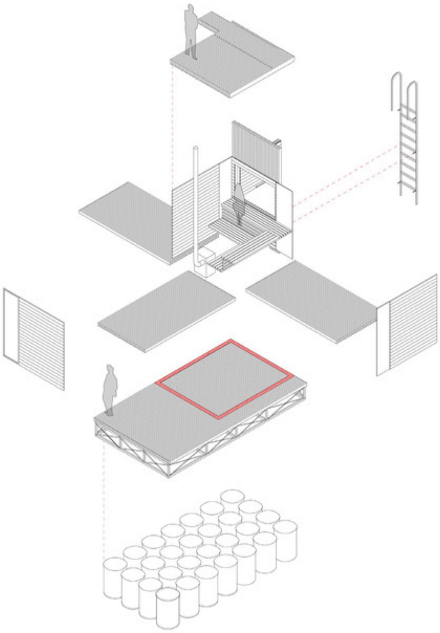


Figure 6.7: wa sauna separate parts[5]

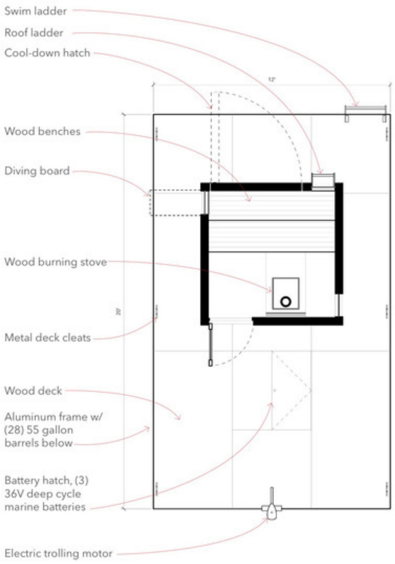


Figure 6.8: Plan[5]

6.4 Floating House / MOS Architects

This project intersects a vernacular house typology with the site-specific conditions of this unique place: an island on Lake Huron. The location on the Great Lakes imposed complexities to the house's fabrication and construction, as well as its relationship to site. Annual cyclical change related to the change of seasons, compounded with escalating global environmental trends, cause Lake Huron's water levels to vary drastically from month-to-month, year-to-year. To adapt to this constant, dynamic change, the house floats atop a structure of steel pontoons, allowing it to fluctuate along with the lake.

Figure 6.9: Floating House / MOS Architects[4]

The formal envelope of the house experiments with the cedar siding of the vernacular home. This familiar form not only encloses the interior living space, but also enclosed exterior space as well as open voids for direct engagement with the lake. A ”rainscreen” envelope of cedar strips condense to shelter interior space and expand to either filter light entering interior spaces or screen and enclose exterior spaces, giving a modulated yet singular character to the house, while performing pragmatically in reducing wind load and heat gain.[4]

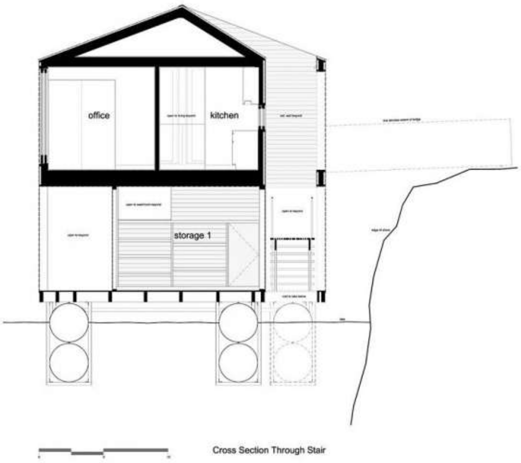


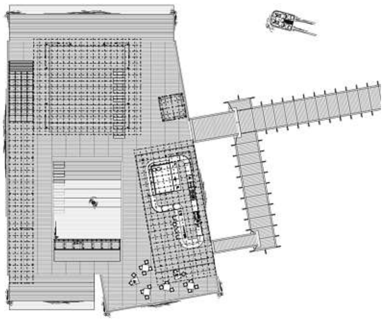
Figure 6.10: Section[4]

6.5 Floating Island ETH Zurich

The Pavilion of Reflections was moored at Bellevue, Zurich. For 100 days, the pavilion will act as a nucleus and focal point for the thousands of visitors to the Manifesta 11 European Biennial of Contemporary Art in Zurich. The pavilion's 150 tonnes of wood and steel had to be hauled by barge across the lake from the Mythenquai to Bellevue. The unique project, which involved some 30 students from ETH Zurich's Department of Architecture, has now been successfully completed.

Figure 6.11: Floating Island ETH Zurich[29]

The Manifesta pavilion is on a different scale altogether: it has a 600m2 footprint, required extensive planning time, and must meet specific requirements. As the pavilion is a public building that can accommodate up to 300 visitors, it has to comply with all fire safety regulations. On top of this, the Manifesta organisers laid down some challenging guidelines: it had to be a floating structure featuring an outdoor swimming pool and toilet facilities, as well as a spectator stand and a large screen for showing films.[29]



Plan[29]

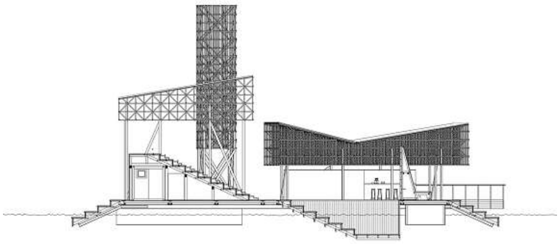


Figure 6.12: Section[29]

6.6 Drie Streken

Drie Streken (Three points of the Compass) is a wooden structure created by the visual artist Marc van Vliet that changes with the tides. The artwork is ‘illuminated’ from three compass points through three large standing mirrors, placed kilometres away, which reflect the sun. Based on the sun and the tidal forces (and the moon), the artwork’s form change with the tide. This almost imperceptible variation occurs twice a day.

Figure 6.13: Drie Streken[31]

Visitors can reach the wooden artwork on foot: during ebb across the mudflat, and during tide across the 100-metre-long pedestrian bridge. It is a meeting place that offers a different perspective on the vastness of the Wadden landscape by the hour and the day. The visitor’s gaze is directed outwards during the ebb tide, and inwards during the flood. A rough version of this artwork was displayed at the Oerol festival in 2015, and it has since been further refined and adapted, so it can be set up in different parts of the Wadden Islands. As part of the European Capital of Culture celebrations in 2018, the Drie Streken artwork will be on display in the Wadden Sea at Hoek van de Bant.[31]

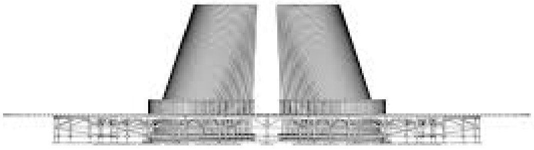


Figure 6.14: Elevtion[31]

6.7 Archipelago Cinema

Archipelago Cinema, an auditorium raft designed to float on the sea, premiered at the inaugural edition of the Film on the Rocks Yao Noi Festival, curated by Apichatpong Weerasethakul and Tilda Swinton. The Festival, which took place from 9th- 12th March 2012, is set to become an annual meeting place for art and film.

Figure 6.15: Archipelago Cinema[6]

A work with a strong connection to the local community, Archipelago Cinema is based on the techniques used by fishermen to construct floating lobster farms. The raft is built out of recycled materials as a series of individual modules to allow for flexibility for its future use. Subsequent to a journey which will see the raft travel to further places as an auditorium for other film screenings on water, it will eventually return to the island and be donated to its actual builders, the community of Yao Noi, as its own playground and stage in the ocean. Archipelago Cinema is a collaboration between Studio Ole Scheeren and the Film on the Rocks Yao Noi Foundation, founded by Nat Sarasas, Chomwan Weeraworawit and Apichatpong Weerasethakul. It is the first project of Studio Ole Scheeren since he established his architecture practice, Buro Ole Scheeren, in Beijing and Hong Kong in 2010.[6]

6.8 Schoonschip

Schoonschip is a sustainable, circular, residential community of floating houses in Amsterdam. Schoonschip site is currently still under development and completion, but since the beginning of 2020 a total of 46 floating houses and just over 100 residents are living there. Together with Waterstudio and Metabolic, the ideas of the Schoonschip initiative group has been translated into a smart urban plan by SpaceMatter. The team aimed to create Europe's most sustainable floating community.

Figure 6.16: Schoonschip

The site is energy self-sufficient, employs circular building practices and serves as a showcase for sustainable living. A smart jetty connects the 46 floating households with each other and the quay.On the top surface, the jetty is a social connector where people meet. Down below the surface, the jetty is a functional and sustainable connector with all the energy, waste and water lines attached to every household connected.[8]

7 Design process

The proposed House is a modular solution that can attach itself to a platform and floating completely on the water, but at the same time The houses ascend when waters rise and descend when waters recede. the reason for this kind of design is to reduce the wave shocks and bringing more comfort to the building

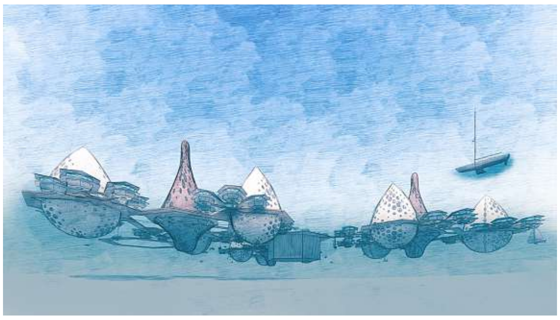


Figure 7.1: Floating district (Rhino-Lumion)

7.1 Stability

in the design process, one of the challenges was to balance the weight of the building in a way that it would float without problem on the water In the first stages of design, the focus was on spreading the building's weight on four sides of its structure so that it could provide equilibrium and stay stable and react in a balanced way to wave forces

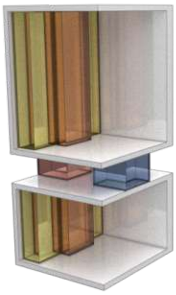
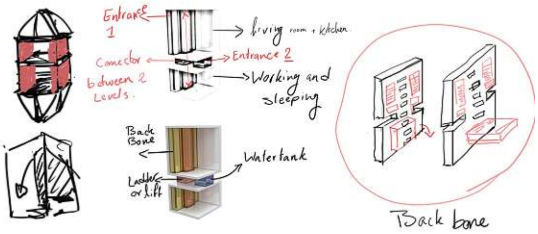
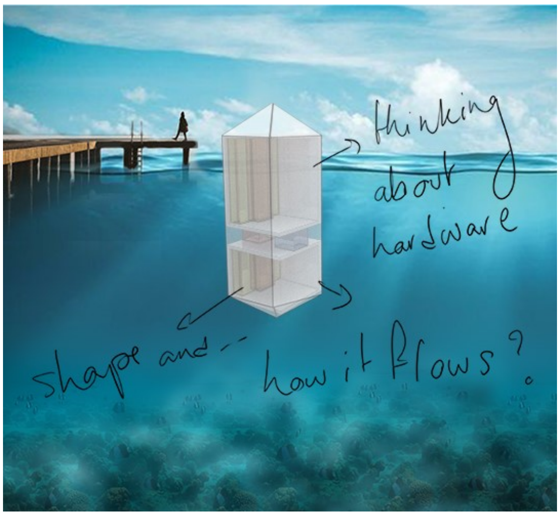


Figure 7.2: (Rhino-Vray)

The first illustration shows how the building started to take shape as a cubic vertical object. By understanding the principles of floating objects and finding out that more surface means more stability and fewer wave shocks the concept of making the floating platform took shape





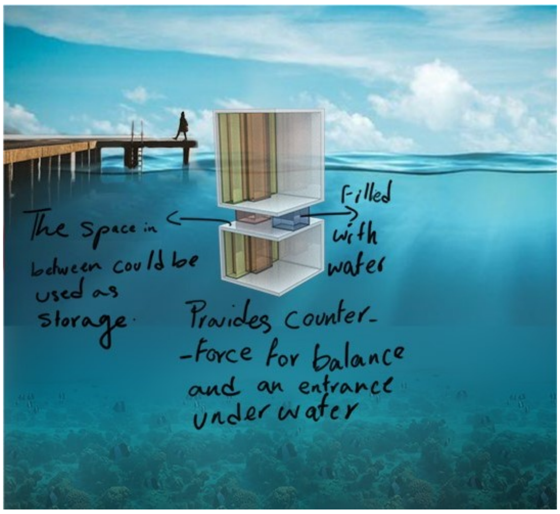


Figure 7.3: (Rhino-Vray-Photoshop)

further in the design process, as the building evolves to a hexagonal shape, the platform evolves from a rectangular shape to a larger hexagonal and increases its size. The load of the building separates itself around a vertical core in the center of the structure, and the building's form gets closer to a swimming tube and spreads the load around its vertical hub.

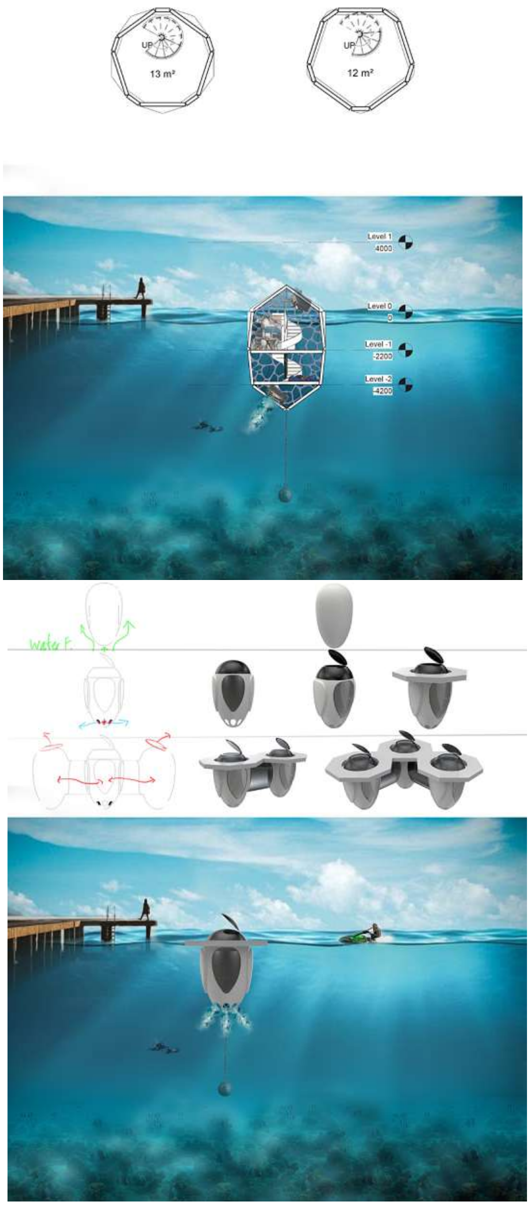


Figure 7.4: (Revit-Rhino-Vray-Photoshop)

In this phase, the project turned into a half-cylindrical hub. However, it functions correctly with the rectangular platform around it. The design's shape and height made it very hard to create a space with the necessary qualities for permanent living; the problem was solved by re-designing the whole shape and optimizing it.

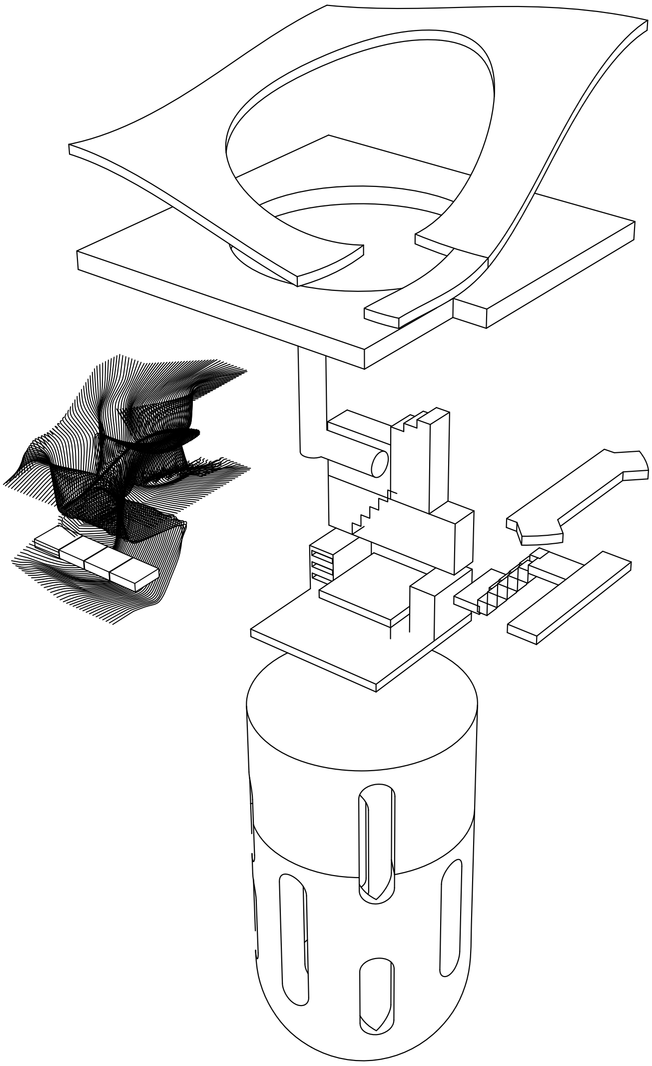


Figure 7.5: Seperated parts of the Floating House in Early stages of design (Rhino)

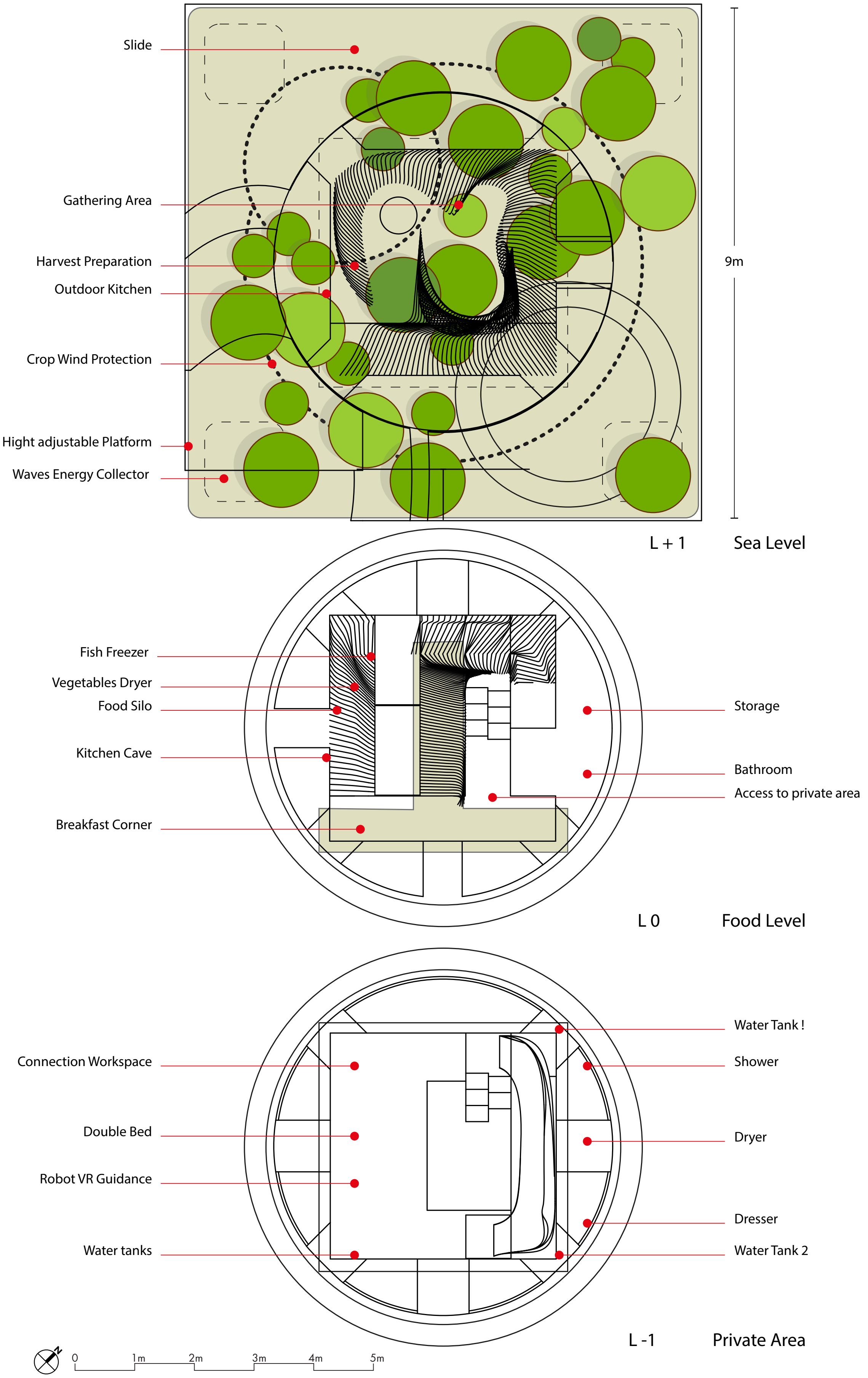


Figure 7.6: Functionality of the Floating house in Early stages of design SC:1/100 (Rhino-Illustrator)

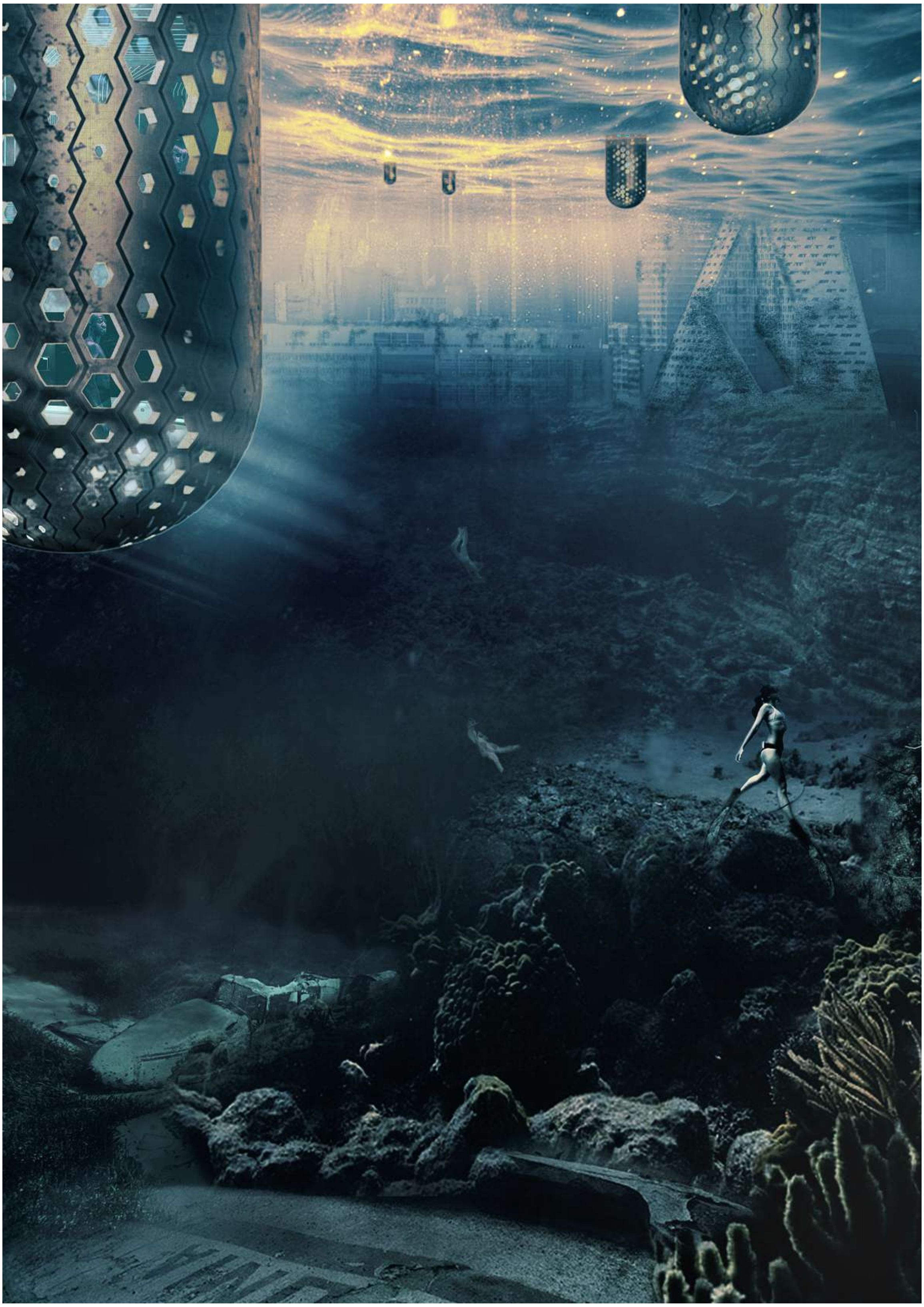


Figure 7.7: Floating Pods, floating on Floded Newyork 23.Feb.2087 AC. (Rhino-Vray-Photoshop)

7.2 Optimizing the Shape

When bees make hexagons in their hives, the six-sided shapes fit together perfectly. Circles would leave gaps in the honeycomb. Squares and triangles wouldn't leave gaps, but the hexagon works even better. The hexagon uses the least amount of material to hold the most weight. what makes this particular shape so interesting is that the hexagonal shape best fills a plane with equal size units and leaves no wasted space. Hexagonal packing also minimises the perimeter for a given area because of its 120-degree angles.

Figure 7.8: Worker (female) honeybees crawling inside the cells of a honeycomb.(Photo byMeggyn Pomerleau)

For this matter, the platform changes its shape from a rectangle to a hexagon. This decision gives the building variety of possibilities.

Figure 7.9: Design evolution process (Rhino-Vray)

In this project phase, the assumption was a floating off-grid building, which was changed further in the design prosses of the project—based on the complexity of producing basic needs for a healthy and safe life in complicated circumstances like water.

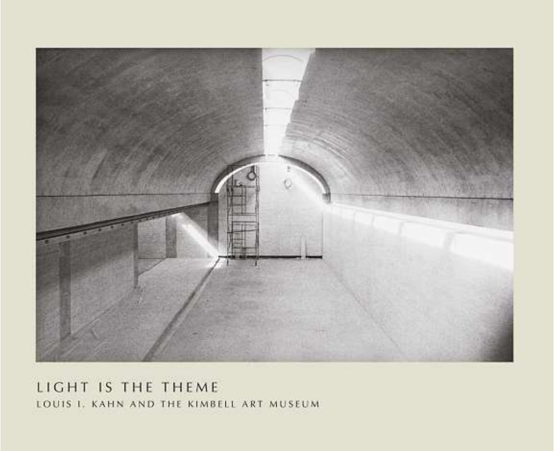


Figure 7.10: Light Is The Theme Louis I. Kahn and the Kimbell Art Museum (Photo by Eric M. Lee)

Living on the water means receiving a considerable amount of light and reflection to control the amount of light imported into the house. Fixed windows took place on the upper part of the house, and the roof works as a shader on top of the house to provide indirect light for the house. The shader controls the amount of light the house receives and is also covered with photovoltaic panels to provide renewable electrical energy for the house.

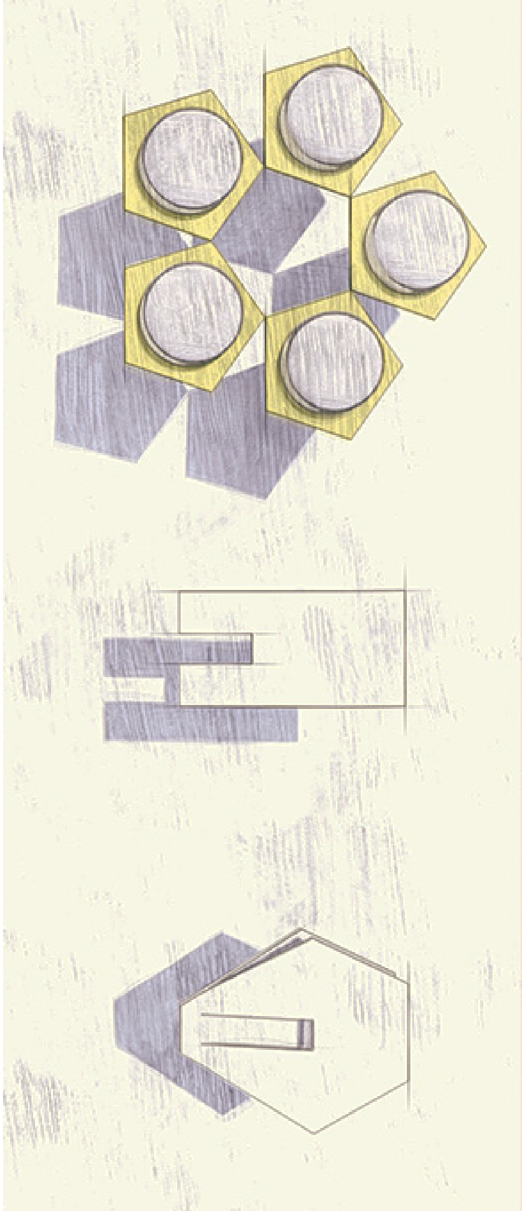
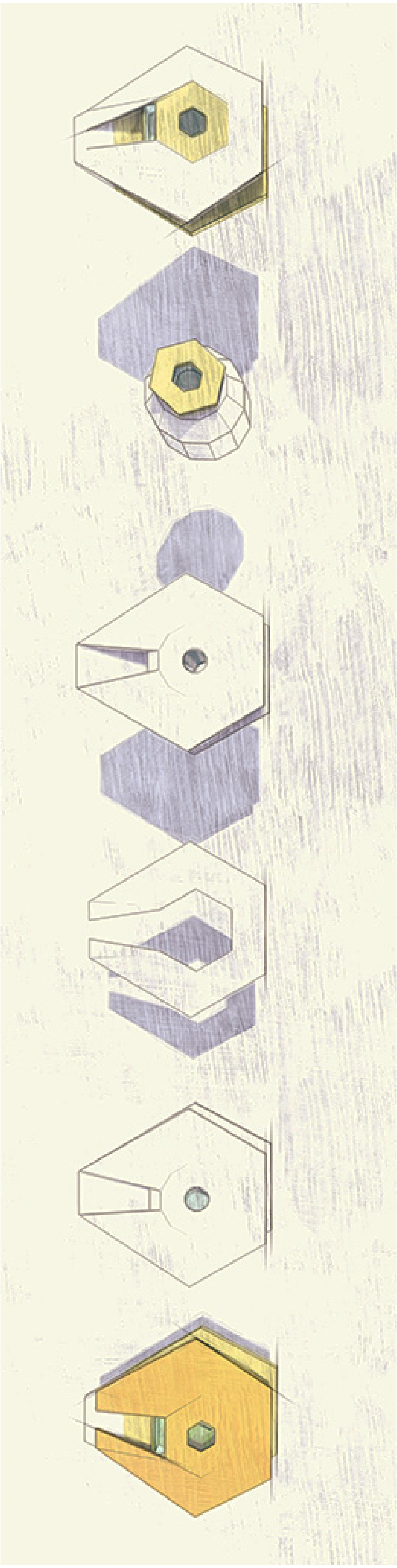


Figure 7.11: The platform starts to take shape, the design of the house evolves, and the shader appears on the roof.(Rhino-Lumion)



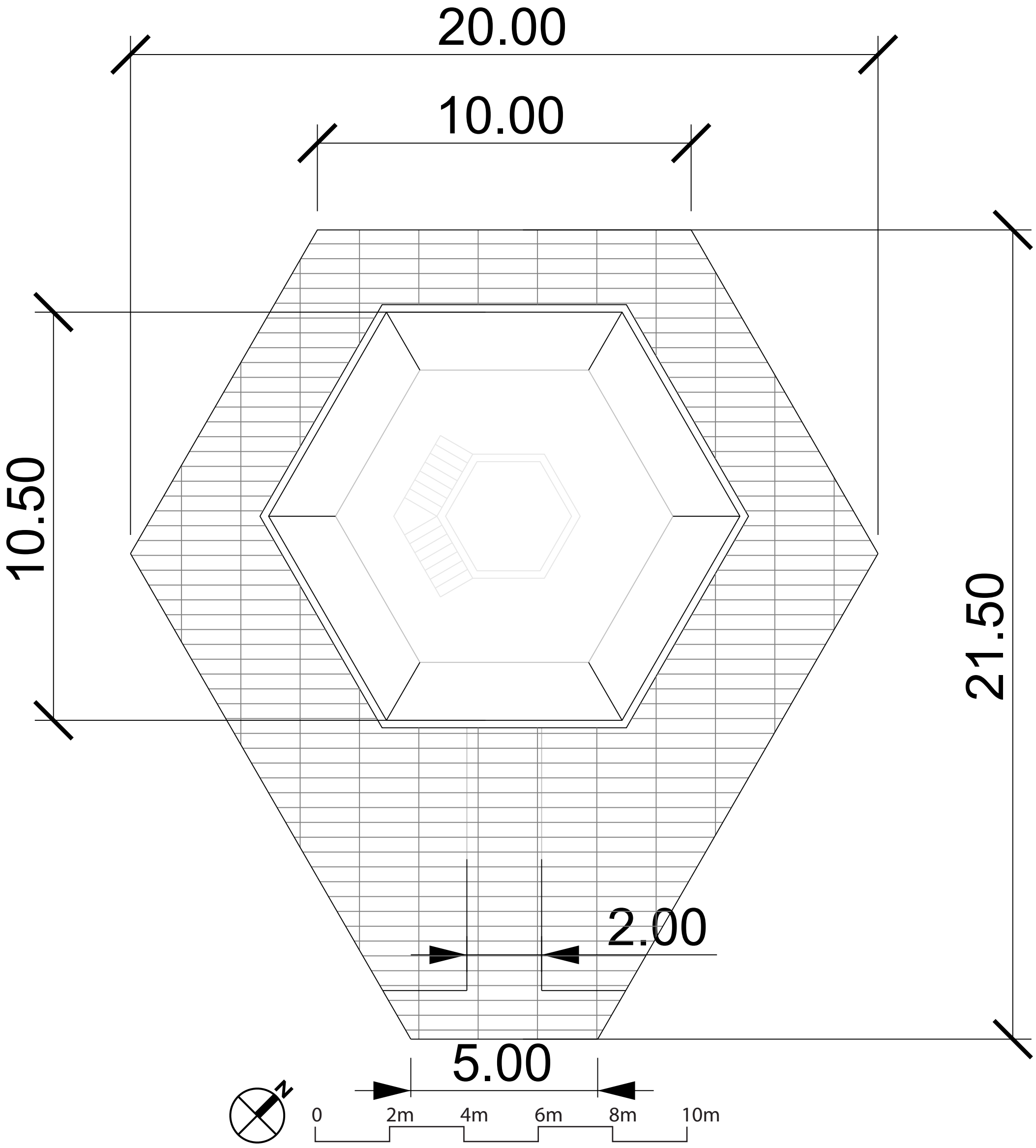


Figure 7.12: Proportions of the House SC:1/200 (Rhino)

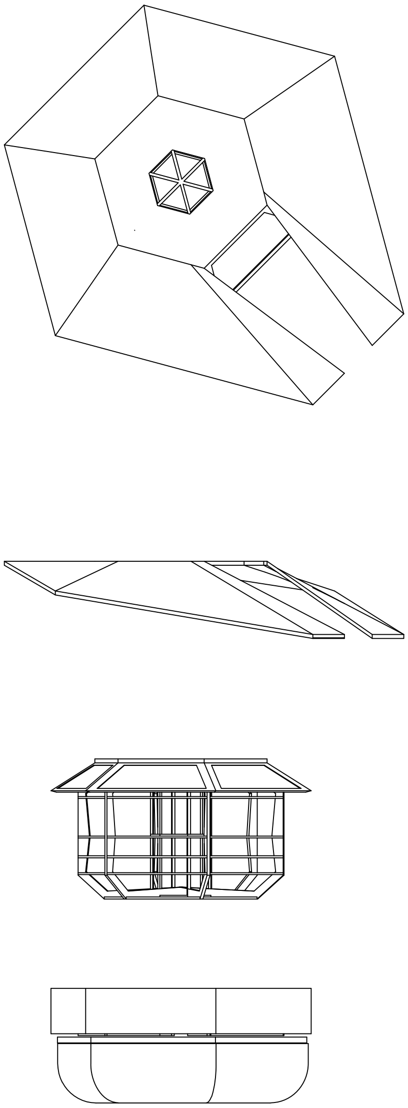
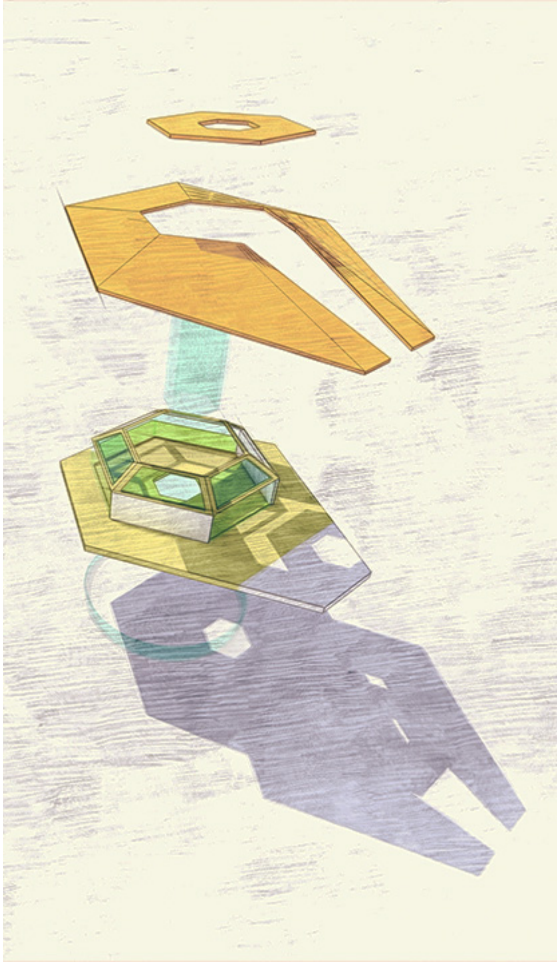


Figure 7.13: Main parts of the building showed separately consists of the Roof, Main structure, and the surrounding case (Rhino)



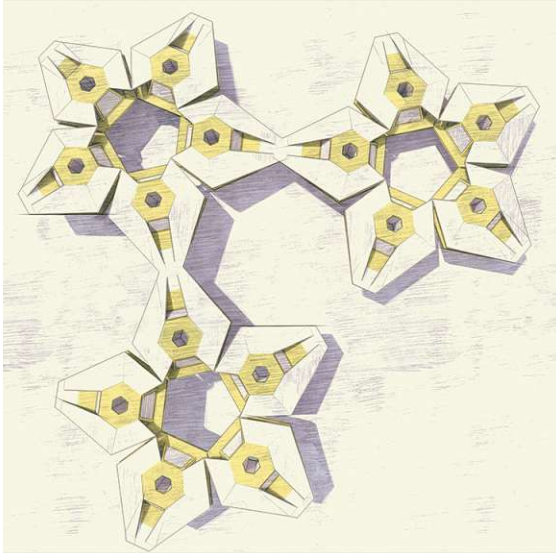


Figure 7.14: Main parts of the building showed separately.(Rhino-Lumion)↑
-Figure 7.15: The building parts together.(Rhino-Lumion)↗
-Figure 7.16: The buildings ability to connect each other.(Rhino-Lumion)→

At this design stage, the floating platform around the house receives an extra part that makes it possible for the houses to attach to another platform. Using the hexagonal geometry makes it possible to arrange them perfectly around each other, bringing more possibilities for a social life in the future stages of the project.

8 Naval Architecture and Structure

The presented project is not only floating on water, but also a part of it sinks underwater; for that matter, it would be essential to have an understanding about Naval architecture and its structure, how ships float on water and submarines sink and withstand the pressure underwater. this knowledge would be critical for designing the Structure of this project.

8.1 Structure Design Of Ship

The upper part of the stern of a ship extends abaft of the rudder post. And there is special arrangement of framing to support it. This framing is mainly carried by the transom which consist of deep and heavy floor securely attached to the rudder post in association of transverse frame and beam. These are known as Transom Floor, Transom Frame and Transom Beam. Transom floor has same depth as that of depth of cellular double bottom, but must be slightly thicker.[23]

- **Cruiser Stern**
  a system of ordinary transverse framing supported by an intercoastal girder at the centre line. This girder has to be doubled , just abaft the transom floor, to allow the rudder stock to pass. A number of cant frame are fitted abaft the aftermost transom frame.The frame should be of same size as bulb angle frame in peaks and are extend to the strength deck. The frame space is not to exceed 610 mm. Where extra strength is required web frames may be required and also extra longitudinal girders to support it.[23]

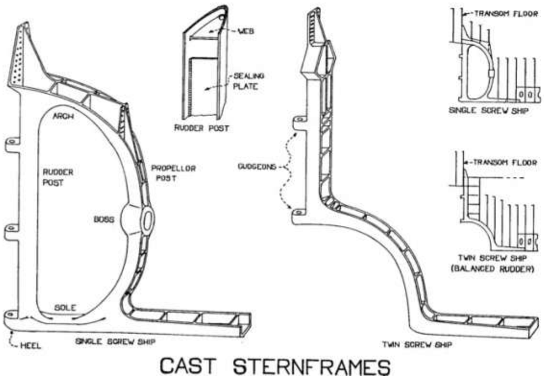


Figure 8.1: Sternframes[23]

- **Transom Stern**
  same as cruiser stern, except that can't frame at the after end is omitted and is replaced by a flat plate called transom.[23]

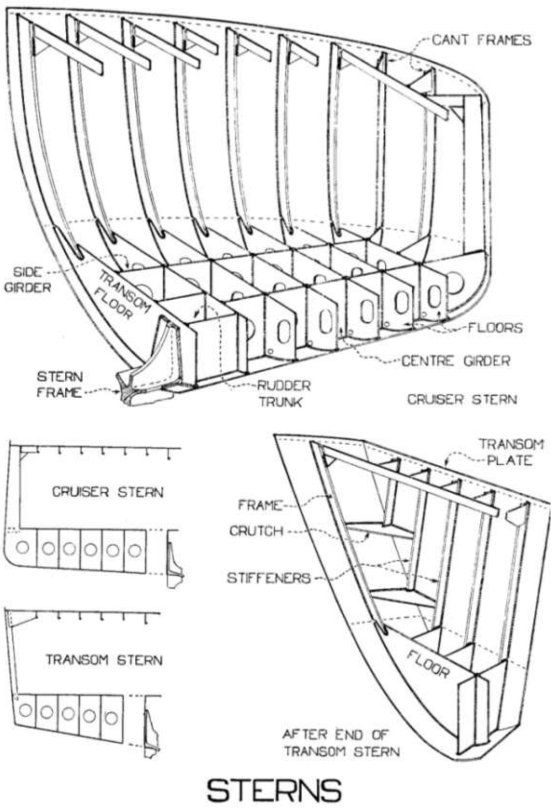


Figure 8.2: Sternframes[23]

8.2 Structure Design Of Submarine

Approximately 40% of the focus and priority in the entire submarine design process is given to its structural design. The full process of designing its structure also takes up majority of the time, as it is not only related to strength factors, but also to a nexus of functional aspects that are interrelated to it. Structural design always begins with the process of identifying the loads that the structure would be subjected to. The loads on a submarine during its mission can be classified into the following:

- **Loading Due to Diving Pressure**
  Depth is one of the most important and deciding structural design criteria. The pressure hull is the primary structural element of the submarine, and is designed to be able to withstand the external hydrostatic pressure. It is designed for a particular collapse depth, at which complete failure is expected within a very narrow range. The collapse depth is actually calculated by multiplying the maximum operable depth (MOD) or service depth with a factor of safety. The hydrostatic pressure at this depth is considered as the design pressure for all the pressure hull calculations. In usual design, safety factors of 1.5 are used, and submarines designed to such limits should not go below the service depth. Whereas, in designs allowing higher safety factors like 2.5, they can dive deeper than the service depth, but only in emergency conditions.[35]

- **Shock Loads**
  A submarine is designed to withstand the loads generated by underwater detonations (for example, mine explosions, pressures generated by bursting of large underwater gas bubbles).The physics of underwater explosions is a very interesting subject, as in, it is remarkably unique when compared to an explosion in air. To understand it, watch the video below, and notice how the explosion ball is created and how it contracts and explodes again, to release a cloud of gas bubbles.[35]

- **Other Loads**

  Like a surface ship, a submarine in surfaced condition is subjected to longitudinal bending loads, transverse shear forces on transverse structures, and torsional loads caused due to wave action. Local loads like longitudinal and torsional vibrations are caused by action of engine. The structure is to be so designed that the level of vibrations are well within the limits.[35]

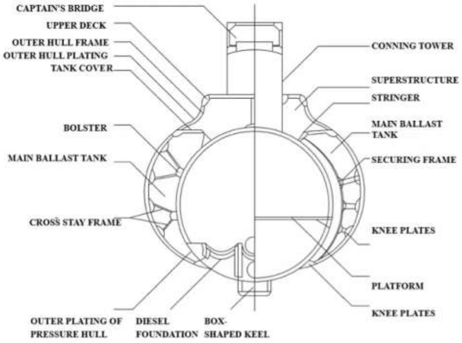


Figure 8.3: Section of a submarine's structure.

8.2.1 Strength of the Pressure Hull

The cylindrical pressure hull in dived condition is subjected to longitudinal compressive stress. This longitudinal stress is of half the magnitude of the hoop stress or the circumferential stress. The following expression for the longitudinal stress on the pressure hull is used for obtaining the required thickness of the hull and the scantlings of the stiffeners required to prevent failure of the pressure hull by buckling.[35]

$$\textit{Longitudinal Compressive Stress on Pressure Hull} = \frac{\textit{External Pressure} \times \textit{Radius of pressure hull}}{2 \times \textit{Thickness of Pressure Hull Plate}}$$

The longitudinal stress therefore is a function of the external pressure, the radius of the pressure resistant hull, and the thickness of the hull plate. Now, what role does a submarine designer play with this equation? The radius of the pressure hull is an input from the client, as in, the radius of the submarine is specified along with a range, and this would mean that the pressure hull radius is a fixed entity for the entire structural design.The hydrostatic pressure at the collapse depth is considered as the external pressure in this calculation. Since the collapse depth is also specified in the contract, it remains fixed. The remaining variable in thickness of pressure hull. Now, the maximum longitudinal compressive stress on the pressure hull is determined by the yield strength of the material used. What a designer calculates for a particular material, is the minimum thickness that is required to keep the stress within limits.[35]

$$\textit{Minimum thickness of pressure hull} = \frac{\textit{External Pressure} \times \textit{Radius of pressure hull}}{2 \times \textit{Yield Strength of pressure hull material}}$$

The following observations can be made from the above relation:

- For a fixed MOD, a submarine with larger diameter requires thicker pressure hull plate than a submarine with lesser diameter.
- The minimum thickness of the pressure hull required for a submarine can be reduced by using material with higher yield strength. A lesser thickness would be advantageous in reducing the weight, but comes at a cost of higher price.

The pressure hull shell absorbs all the forces in the longitudinal direction without the requirement of transverse ring stiffeners. However, the shell is stiffened by ring stiffeners that can absorb the circumferential stresses originated due to buckling loads. The ring stiffeners (usually T profiles) are welded to the pressure hull shell, and the entire system acts as one unit.[35]

8.2.2 Structure Design Of Floating House

Learning from the Naval Architecture helped the structure design of the floating house. It has to float and sink simultaneously—a combination of a Boathouse and part of the Submarine challenges in designing the structure. Reinforcing the surface based on the understanding of water pressure on the different parts gave shape to the idea that the surrounding shell is the body's skin for this intelligent house which will sustain a long life on and in the water. The structures are like the rib bones which protect the living area (The Heart of the building). The Ribs connect to the core structure, which works as the house's spine.

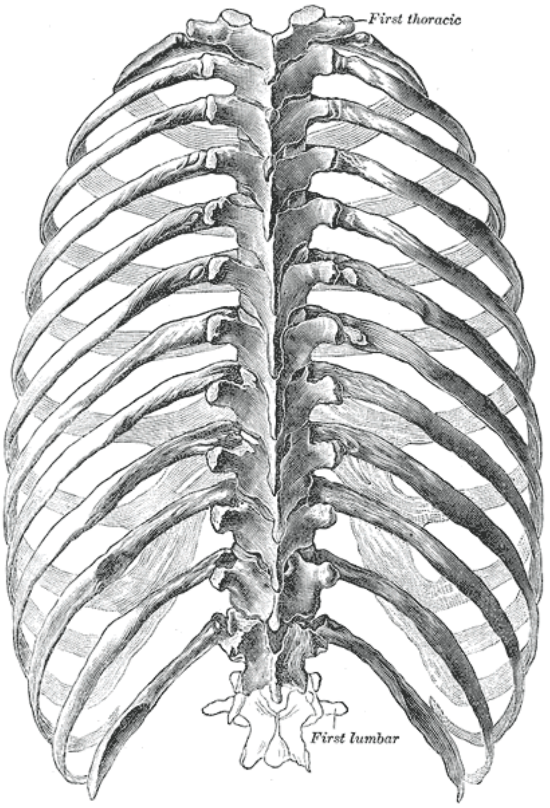


Figure 8.4: Posterior view of ribs and their articulating vertebrae partners. (Image credit: Wikipedia 2011).

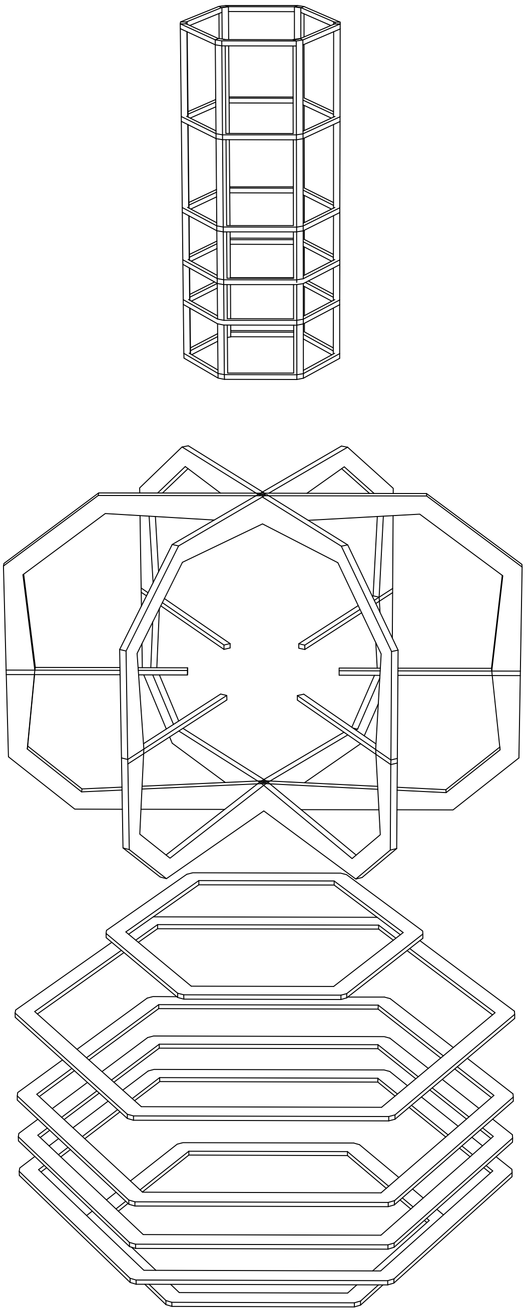


Figure 8.5: Structure of the house in separate Parts (Rhino)

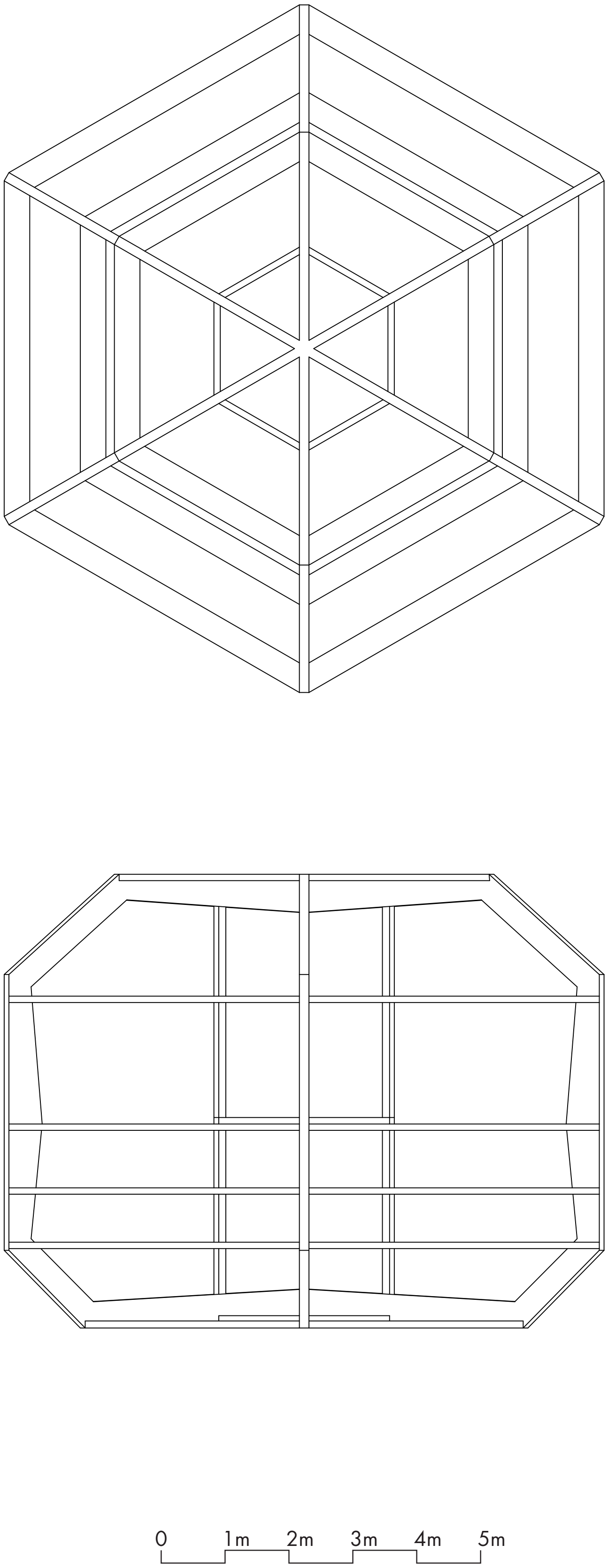


Figure 8.6: Structure of the house (Rhino) SC:1/100

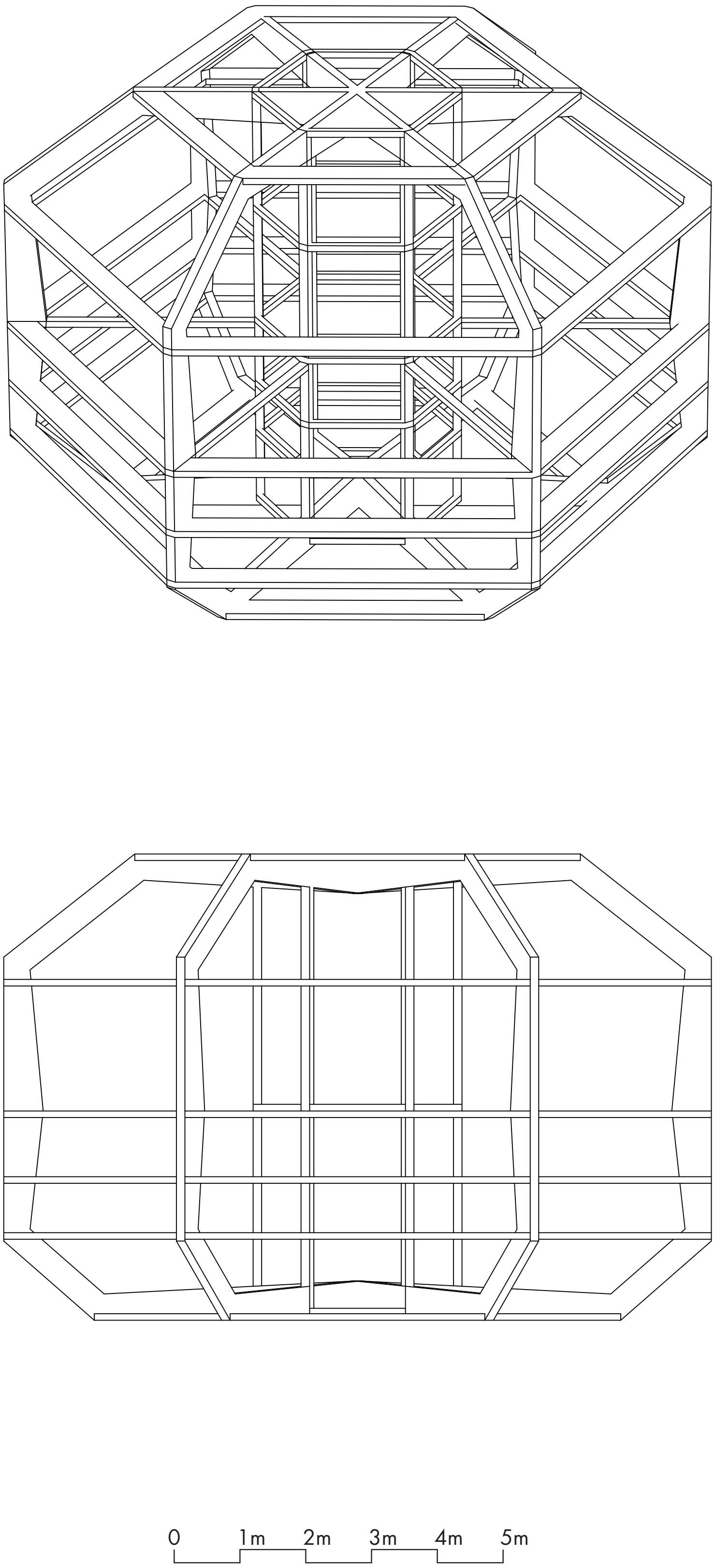


Figure 8.7: Structure of the house (Rhino) SC:1/100

8.3 Buoyancy

For controlling the floating ability of the house on the water, the algorithmic analysis helped the project. The project is designed in Revit, for that matter, by using a grasshopper inside Revit and writing a simple script that calculates if the building will float or it would sink or how much weight would be needed to add to the floating house so that it can flow properly. Based on this script, the building's sensors around the platforms will react based on the water level around the building. The computer will calculate either lack of weight or extra weight. By feeding these pieces of information to the integrated computer in the house, it can decide if it is necessary to add or reduce the weight of the building. And it automatically balances the building and controls its Buoyancy

8.3.1 Algoritmic Design and Analysis

Algorithm Design and Analysis. A study of the design and analysis of algorithms as solutions to problems, including dynamic programming, linear programming, greedy algorithms, divide-and-conquer algorithms, graph algorithms, and intelligent search algorithms. In this Project, by calculating the total weight the building has based on the Material used in the shell, the walls, and the structure, I defined an algorithm in grasshopper inside Revit that divides this weight with a simple formula; for each Ton, there's a need for one cubic meter of sinking volume.

8.3.2 Rhino Inside Revit

Rhino. Inside is an innovative technique for embedding Rhino into other 64-bit Windows applications. Rhino. Inside. Revit is based on this technology and provides a platform for an unprecedented integration of Rhino with Revit. In fact, it is an add-on for Revit to load Rhino and its plug-ins (e. g. Grasshopper) into Revit memory, just like all other Revit add-ons. Grasshopper contributes a range of new components to interact with Revit, as well as to provide access to the two Application Programming Interfaces (APIs) using its scripting components.

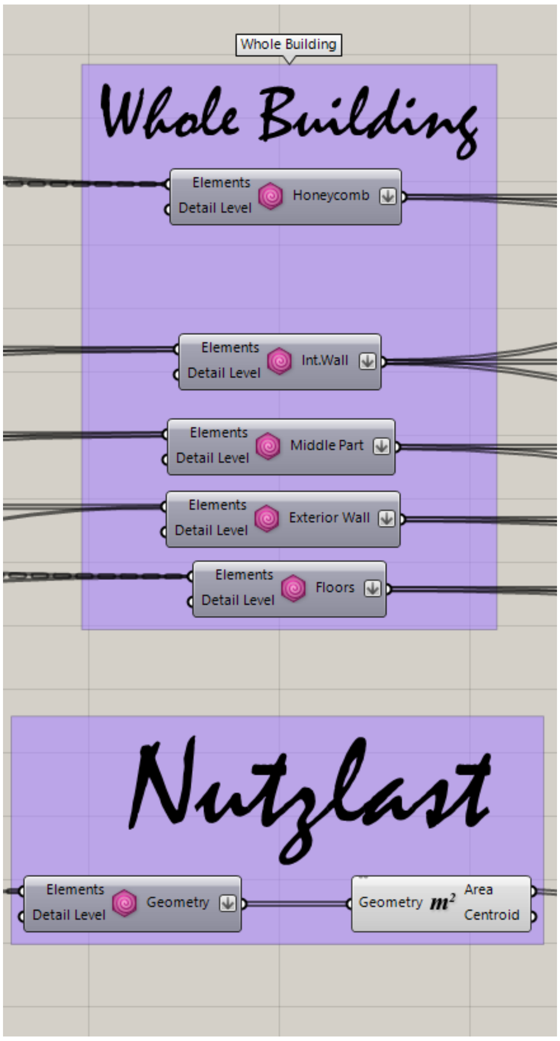


Figure 8.8: Feeding the components with Material density information to recieve the whole weight of the building based on the Grasshopper inside Revit (Revit-Grasshopper)

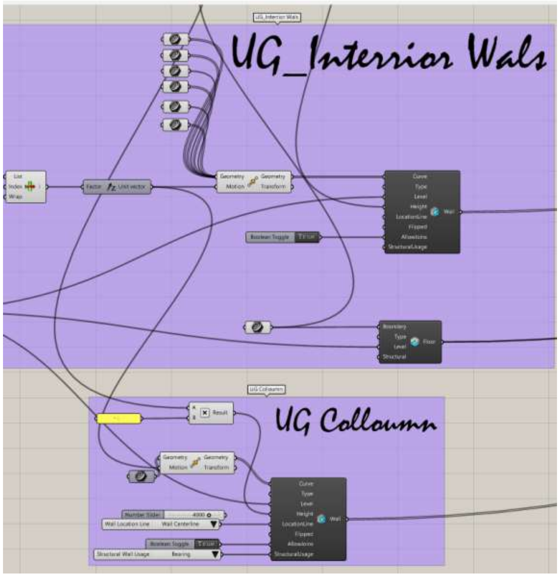


Figure 8.9: (Revit- Grasshopper)

By defining different Materials and their specific density as the variables, grasshopper calculates the weight of the Floating house based on the amount of the Material found on Model information in the BIM program (Revit)

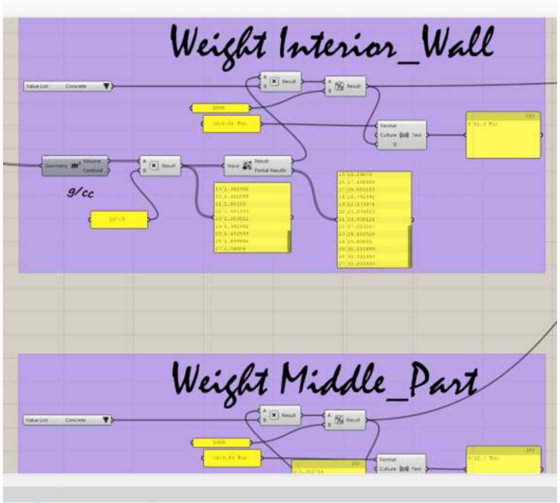


Figure 8.10: Weight of different parts of the Project by feeding Material (and its density)as the variable to the algorithm.(Revit

the following photos present the way the script works

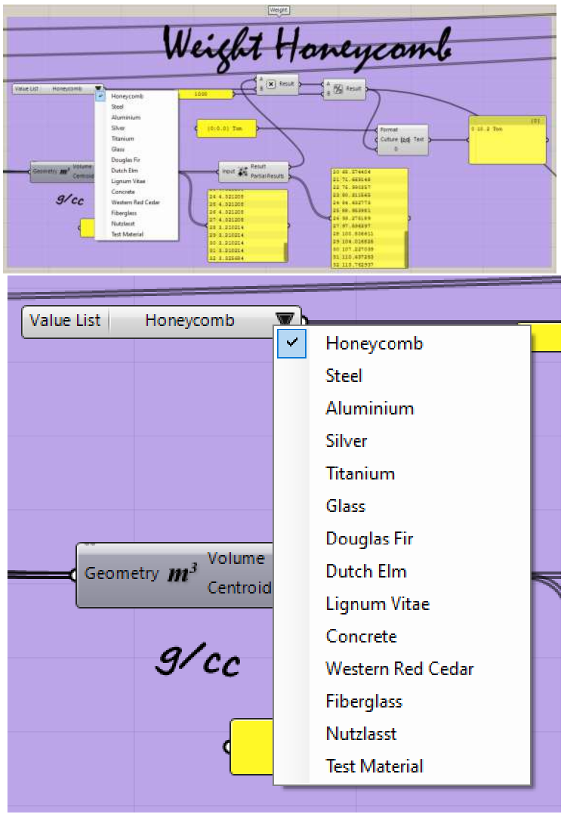


Figure 8.11: Material Pallet (Revit-Grasshopper)

8.3.3 Galapagos

Galapagos is a component in Grasshopper that can optimize a shape to best achieve a user-defined goal. Galapagos needs a series of options or genes to try out and a defined goal or fitness value for this to work. Galapagos is a component in Grasshopper that can optimize a shape to best achieve a user-defined goal. Galapagos needs a series of options or genes to try out and a defined goal or fitness value for this to work. Galapagos helps designers to solve complex calculations and form findings based on different situations. My approach was not about form finding but calculating a simple goal: the Minimum distance between the center point of the building and the water level based on the defined parameter, like weight and volume.

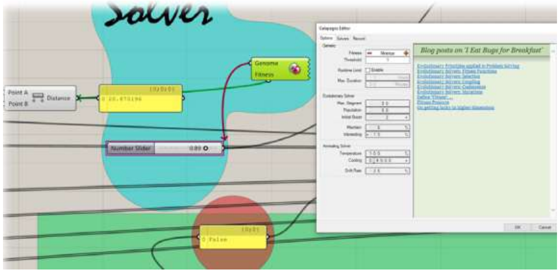


Figure 8.12: Galapagos as problem solver(Rhino.inside-Grasshopper)

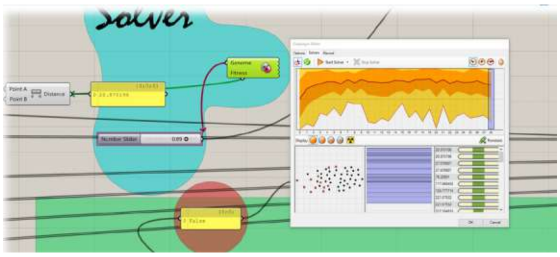


Figure 8.13: Galapagos calculates the Minimum distance between House center point and Water Level(Rhino.inside-Grasshopper)

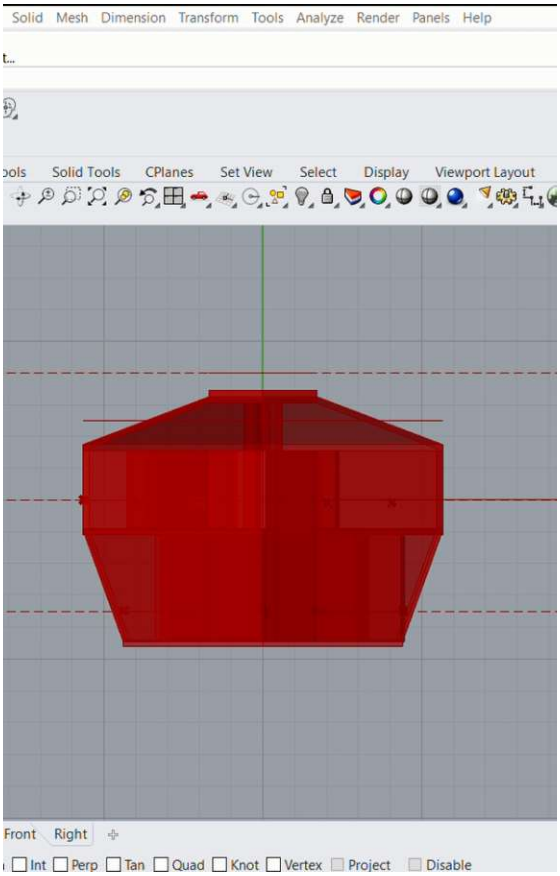


Figure 8.14: The middle line in the photos suggest the water level. If the central part of the building stands on Top of the line, it will float on water; otherwise, it will sink.(Rhino.inside-Grasshopper)

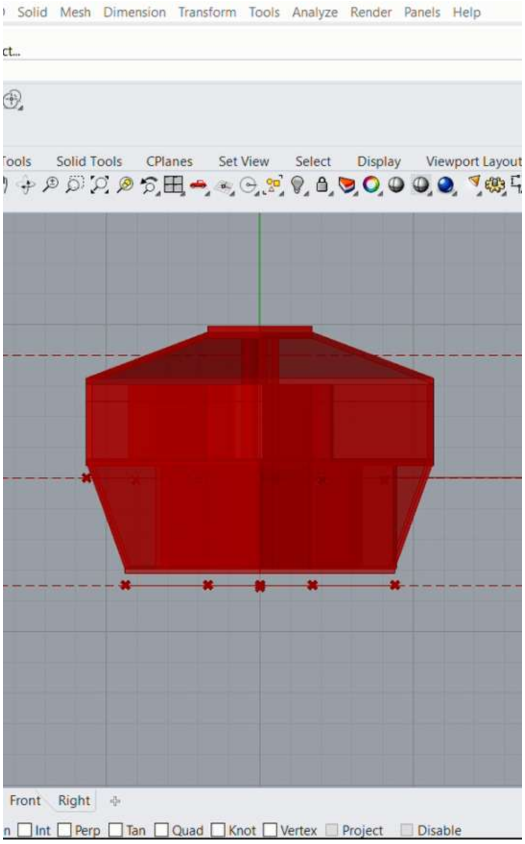


Figure 8.15: The building floats when the calculations based on Weight and Volume are positive and the results are "True".(Rhino.inside-Grasshopper)

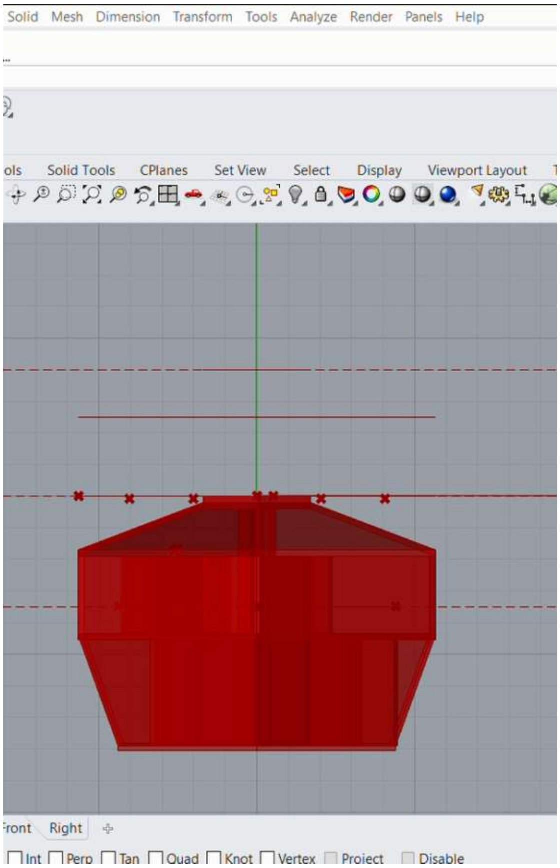


Figure 8.16: Floating house sinks when the calculations based on Weight and Volume negative and the results are "False".(Rhino.inside-Grasshopper)

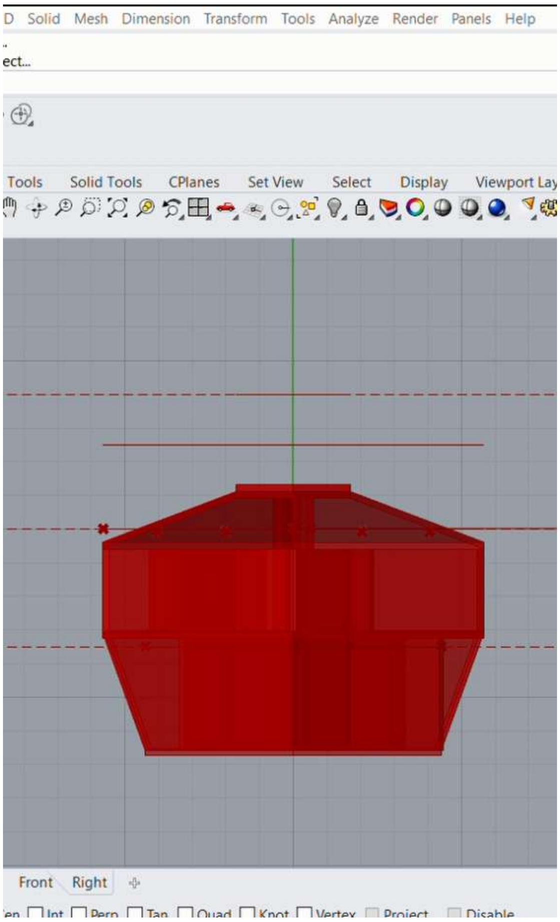


Figure 8.17: (Rhino.inside-Grasshopper)

Floating or sinking, in both case scenarios, the central part of the house has to bring itself to the closest point to the water level. For example, if the results show that the main point of the house is floating higher than the water level, the computer has to calculate the extra weight that needs to be added to the building or vice versa. This extra weight would be stored in a Ballast Tank by surrounding matter, "the water."

8.3.4 Ballast Tank

A ballast tank is a compartment within a boat, ship or other floating structure that holds water, which is used as ballast to provide hydrostatic stability for a vessel, to reduce or control buoyancy, as in a submarine, to correct trim or list, to provide a more even load distribution along the hull to reduce structural hogging or sagging stresses, or to increase draft, as in a semi-submersible vessel or platform, or a SWATH, to improve seakeeping. Using water in a tank provides easier weight adjustment than the stone or iron ballast used in older vessels, and makes it easy for the crew to reduce a vessel's draft when it enters shallower water, by temporarily pumping out ballast. Airships use ballast tanks mainly to control buoyancy and correct trim.

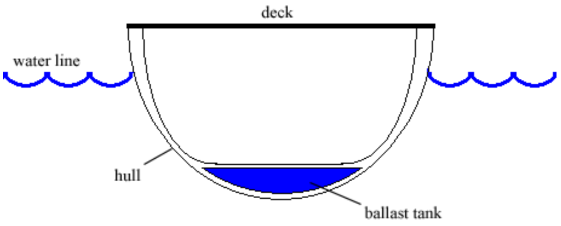


Figure 8.18: Cross section of a vessel with a single ballast tank at the bottom.

- **Ships:** In order to provide adequate stability to vessels at sea, ballast is used to weigh the ship down and lower its centre of gravity. International agreements under the Safety Of Life At Sea (SOLAS) Convention require cargo vessels and passenger ships to be constructed so as to withstand certain kinds of damage. The criteria specify the separation of compartments within the vessel and also the subdivision of those compartments. The International agreements rely upon the states which have signed the agreement to implement the regulations within their waters and on vessels which are entitled to fly their flag. The ballast is generally seawater which is pumped into tanks known as ballast tanks. Depending on the type of vessel, the tanks can be double bottom (extending across the breadth of the vessel), wing tanks (located on the outboard area from keel to deck) or hopper tanks (occupying the upper corner section between hull and main deck). These ballast tanks are connected to pumps which can pump water in or out. These tanks are filled in order to add weight to the ship once cargo has been discharged, and improve its stability. In some extreme conditions, ballast water may be introduced to dedicated cargo spaces in order to add extra weight during heavy weather or to pass under low bridges.

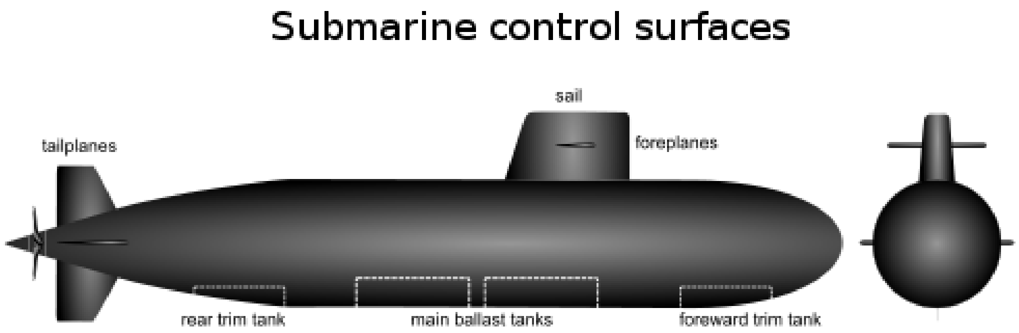


Figure 8.19: Picture was created with Inkscape, Artist:XLerate

- **Submarines:**In submarines ballast tanks are used to allow the vessel to submerge, water being taken in to alter the vessel's buoyancy and allow the submarine to dive. When the submarine surfaces, water is blown out from the tanks using compressed air, and the vessel becomes positively buoyant again, allowing it to rise to the surface. A submarine may have several types of ballast tank: the main ballast tanks, which are the main tanks used for diving and surfacing, and trimming tanks, which are used to adjust the submarine's attitude (its 'trim') both on the surface and when underwater[24]

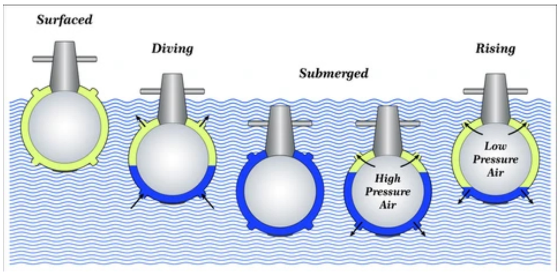


Figure 8.20: Blast Tank in a Submarine

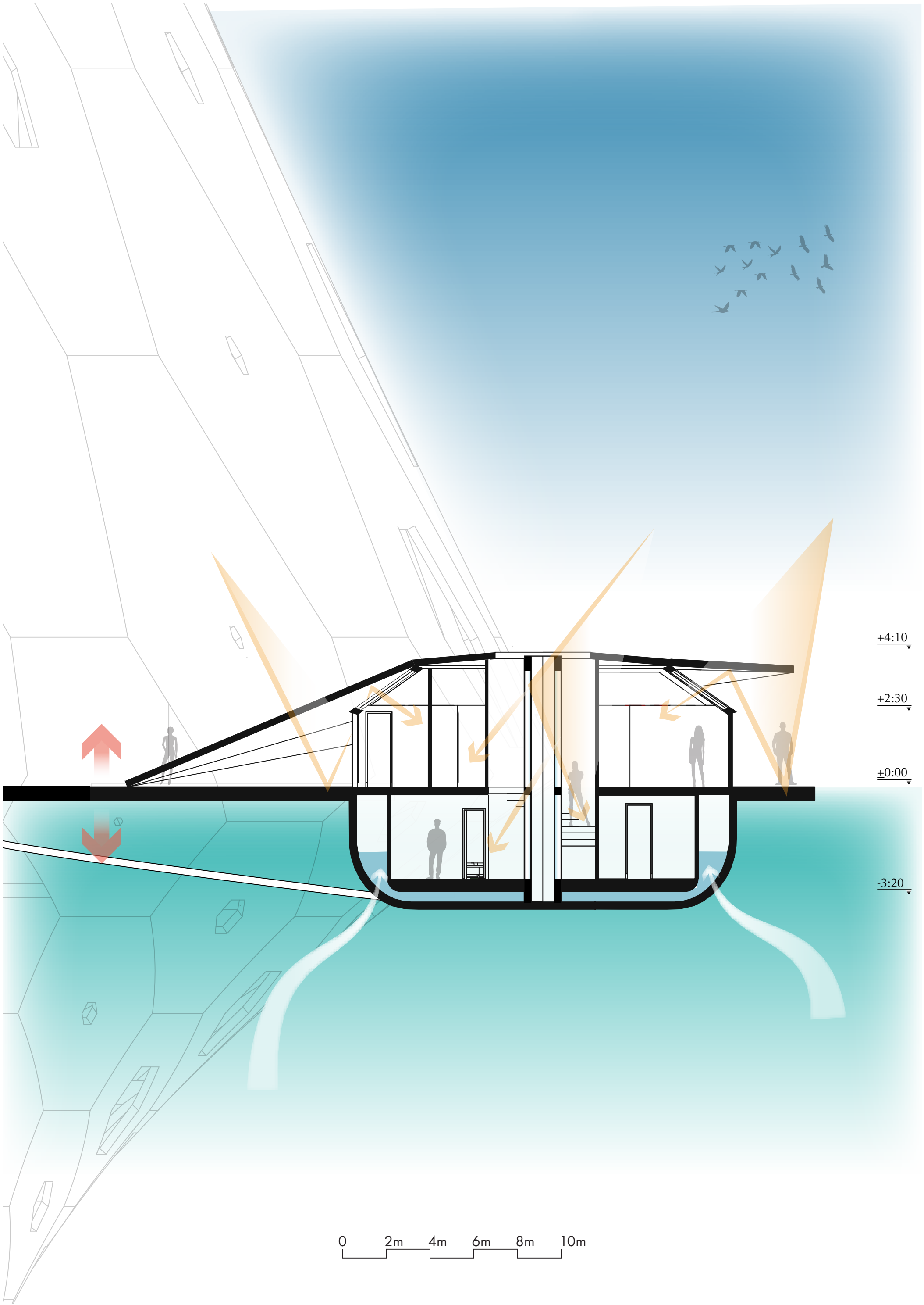


Figure 8.20: Balast Tank in Project's section(Revit-Rhino-Illustrator) SC:1/200

9 Floating House

The building's envelope took shape. The structures of the building support the estimated loads. At the same time, a program calculates if the facility floats on water or sinks. Now it's time for the interior parts of the building, how the house provides living space for a permanent life on the water, for people who may live their whole life, perhaps on the ocean. The issues may occur with rising ocean water levels; a higher water level means less land to provide our needs, food, and the materials we use for construction and production. For that matter, the buildings should sustain a long time.

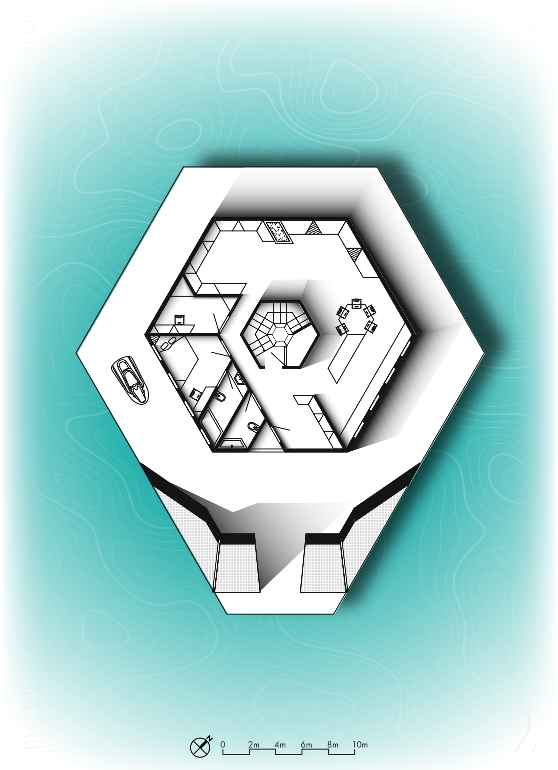


Figure 9.1: Project plan view(Revit-Illustrator)

In this project phase, parameters like sustainability in energy production and design were evaluated. Energy sustainability is highly dependent on the technology in our hands, which advances every single day. As this part is out of this project's studies, it would suffice to have Photo voltaic panels placed on the roof.

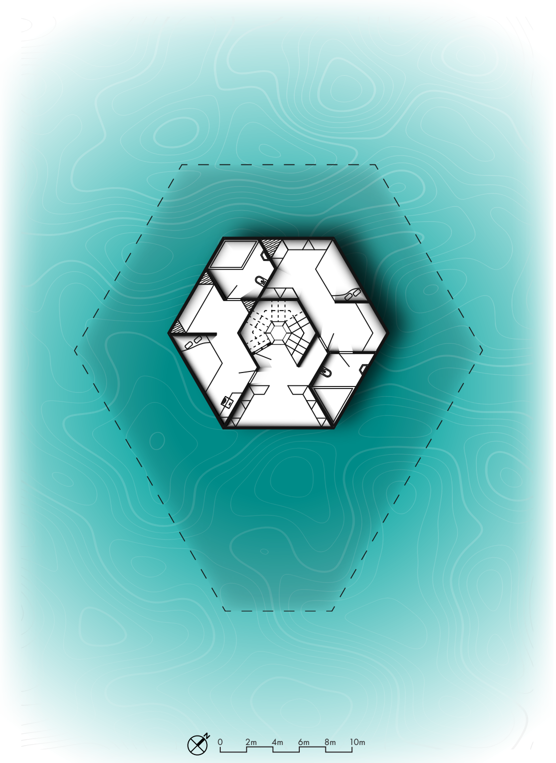


Figure 9.2: Project plan view(Revit-Illustrator)

Design sustainability has to look at the strategy's long-term consequences and provide a design that would last practically without new resources, or the resources would be easy to offer and are renewable and recyclable.

9.1 Sustainability

Sustainable development requires an integrated approach that takes into consideration environmental concerns along with economic development. In 1987, the United Nations Brundtland Commission defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." Today, there are almost 140 developing countries in the world seeking ways of meeting their development needs, but with the increasing threat of climate change, concrete efforts must be made to ensure development today does not negatively affect future generations. The Sustainable Development Goals form the framework for improving the lives of populations around the world and mitigating the hazardous man-made effects of climate change. SDG 13: Climate Action, calls for integrating measures to prevent climate change within development frameworks. SDG 14: Life Below Water, and SDG 15: Life on Land, also call for more sustainable practices in using the earth's natural resources.[37]

9.2 Sustainable Design

Sustainable design seeks to reduce negative impacts on the environment, and the health and comfort of building occupants, thereby improving building performance. The basic objectives of sustainability are to reduce consumption of non-renewable resources, minimize waste, and create healthy, productive environments. Sustainable design principles include the ability to: optimize site potential; minimize non-renewable energy consumption; use environmentally preferable products; protect and conserve water; enhance indoor environmental quality; and optimize operational and maintenance practices. Utilizing a sustainable design philosophy encourages decisions at each phase of the design process that will reduce negative impacts on the environment and the health of the occupants, without compromising the bottom line. It is an integrated, holistic approach that encourages compromise and tradeoffs. Such an integrated approach positively impacts all phases of a building's life-cycle, including design, construction, operation and decommissioning.

Sustainable design is a dedicated effort to create products in a manner that minimizes their negative impact on the environment, making them more economically viable, socially acceptable, and ecologically tenable — is often misunderstood. In the past, many manufacturers viewed efforts to become more environmentally friendly as expenses rather than opportunities However, in today's marketplace, this perspective is proving to be outdated, short-sighted, and fraught with misconceptions. Today, more environmentally friendly and sustainable design can substantially increase revenues, significantly lower costs, and dramatically become a catalyst for innovation and business growth. The growing environmental awareness of consumers, and its impact on purchasing decisions, creates valuable opportunities to produce greener products and generate new revenue streams. Sustainable design can spark innovative approaches and revolutionary new products, and is becoming an important business strategy for controlling operational costs and reducing energy expenditures.

9.2.1 The Future Of Product Development

Too often, manufacturers operate according to a short-term view. While focusing on the present is important for achieving success in the near term, a total fixation on the marketplace as it is today, rather than on making decisions and investments that take into account anticipated changes, can prove to be detrimental to a company's success. Without a long-term view, an organization may be unable to respond to competitive pressures, or be incapable of capitalizing on new green markets and business expansion opportunities.

Consider the breakthrough changes that have occurred over the past few decades, including:

Introduction of green products Rising cost of traditional energy sources Increasing reliance on renewable energy sources Continuing depletion of natural resources Substantial growth in municipal recycling programs Rise in consumer-driven "eco-labeling" programs Adoption of carbon legislation by governments worldwide Launching of major sustainability initiatives by Fortune® 100 companies. Manufacturers that can successfully incorporate sustainable design practices will be positioned to respond to increasing consumer demand and a growing preference for eco-friendly products. They also will be able to stimulate innovation in the development of new products, control development costs through optimized energy and material usage, and boost revenues through product expansion and organic growth.

9.2.2 Benefits Of Sustainable Product Development

Although many manufacturers view sustainability favorably, some remain skeptical about the benefits of sustainable design. How can making your processes more sustainable and your products greener give you an advantage over competitors that don't operate under the same requirements? By providing you with the ability to innovate, sustainable design can produce bottom-line and top-line benefits that give your organization a strategic advantage.

Take compliance, for example. Contrary to popular belief, it actually costs more to manage minimal regulatory compliance for each market in the world than it does to adhere to the most stringent standards throughout your organization. By uniformly meeting the toughest regulations across your enterprise, you can benefit through economies of scale and optimized supply chain operations. Similarly, sustainable design can reduce or control product development costs through improved material usage, alternative manufacturing processes, reduced energy consumption, optimized shipping scenarios, and decreased risk and liability concerns.

The best approach for implementing a sustainable design strategy is to do so in a way that causes the least amount of disruption to your current business operations, while setting the stage to drive sustainability throughout your future business functions. Product development is the natural place to implement sustainable design because it represents your business at its most embryonic point. The design and engineering of a product dictates everything that follows: what the product's made of, how it's made, how much energy it consumes (in use and while it's manufactured), how it's shipped, and what type of environmental impact the product has throughout its lifecycle. Virtually every issue related to sustainability emanates from a product's initial design.

Assessing sustainability at the product development stage is the most logical place to start because decisions made when a product is designed can impact the eco-friendliness and sustainability of subsequent processes in an exponential fashion. Choosing to continue to use an increasingly expensive, scarce, or harmful material, for instance, can have substantial cost ramifications in manufacturing, purchasing, and sales.

When you evaluate a product's environmental impact while it's being developed, you can most effectively communicate sustainability benefits to downstream processes and across your organization. By implementing sustainability practices in product development, you can create the critical mass required to overcome organizational inertia to implementing sustainability practices throughout your enterprise.

9.2.3 A Focus On Lifecycles

What type of information should you generate in product development to facilitate sustainable design? Some companies have undertaken elaborate, detailed Life Cycle Assessments (LCAs) for each of their products to understand how they can apply sustainability to existing products and develop derivative offerings. An LCA is an in-depth, cradle-to-grave analysis of your product's environmental impact throughout every facet of its lifecycle. Although LCAs can be sophisticated and expensive, manufacturers can perform automated lifecycle-based evaluations in software that produce good estimates, which you can use as guidance for sustainable design. The most important step is to start thinking about environmental impacts over your product's full lifecycle.

For example, what are the characteristics of the different stages of a product's lifecycle that hold the greatest potential for damaging environmental impacts? What is the product's carbon footprint — how much CO2 is released into the atmosphere as a result of the manufacture and use of the product? How much energy does the product consume both during use and while it's manufactured? Does your product or production process emit gases and compounds into the atmosphere? Are effluents that can impact vital ecosystems released into waterways during manufacturing or as a result of the use of your product?

In-depth assessments of the impact of a product's lifecycle can be quite elaborate and detailed. For the purposes of product development, LCA thinking, automated solutions, and reliable metrics of environmental impacts, which provide guidance on a design's potential sustainability, represent simpler, more pragmatic approaches to incorporating sustainable design in product development than a full, comprehensive LCA.

Obtaining these types of quick answers provides designers and engineers with the information and confidence that they need to make smart, environmentally friendly design decisions before manufacturing begins.

9.2.4 Adopting Greener Design

The critical role that sustainability will play in establishing strategic advantage has already begun. Most business experts anticipate that sustainability will force companies to rethink their business models to make their products, technologies, and processes more sustainable, not just to achieve regulatory compliance or engender goodwill, but to remain viable and successful.

Manufacturers need more than just assumptions regarding environmental impacts. You need to be able to use LCA thinking to generate reliable estimates of environmental impacts in order to manage the development of greener products and demonstrate the benefits of sustainable design. Software products, such as SolidWorks® Sustainability, are available to help manufacturers implement sustainable design.

For a technology-based solution to be effective in facilitating sustainable design, it must take into account the strategies required to effect this transition. The information generated as a result of LCA-based sustainable design establishes the foundation for the successful execution of the planning, development, manufacturing, communication, and marketing strategies that will drive your company's sustainability efforts forward.

Software allows you to assess and evaluate environmental impacts before making any hard investments in materials or machinery. You can use this information to create breakthrough innovations, introduce new processes, communicate sustainable initiatives, and market greener products. Using sustainability software allows designers and engineers to measure the environmental impact of the products they design in their CAD software. It provides real-time feedback on environmental impacts in four key areas: Carbon Footprint, Total Energy Consumed, Effect on Water, and Effect on Air.

This LCA information is generated through the GaBi database and material/ process model provided by PE International, a leading provider of sustainable design and software services. Applied methods include implementing management systems, developing sustainability indicators, life cycle assessment (LCA), carbon footprint, design for environment (DfE) and environmental product declarations (EPD), technology benchmarking or eco-efficiency analysis, emissions management, and clean development mechanism projects.

9.3 Modularity

**Same, Same,
But
Not the Same**

Every design decision we make comes at a price. Observing the evolution of product design a few decades ago and the similarity of this evolution with nature's development, we'll find out that preliminary design concentrates on disproportionate aspects, like luxury, ornamentation, and so on. These approaches are doomed to extinction and are irrelevant to their producer, nature's evolution, or Mankind's designs as they are not sustainable and use a massive amount of disproportionate resources. A simple example of this evolution in our designs is the noticeable change in our product designs in the last decades. After the Digital revolution, earlier each one of the products we use, like cell phones, had a different shape, hardware, and software with additional capabilities. Today most of the designs of the cellphone are mainly similar. The software is mostly the same, but each is different and personalized based on the user's needs. They look the same, but in fact, they are not. Translating this approach to architecture brings us to Modular design. An Architecture that looks the same on the outside with different contents and motives.

9.3.1 Design by Evolution

Most of the creatures on planet earth live in a sustainable cycle. Nature generally evolves in a way that wouldn't use more resources than its essential needs to survive. On the other hand, humanity employs too many excessive resources, especially after the industrial revolution. We adjust to the fact that we can have way more than our needs. It became an unhealthy habit that brought humans and other creatures to a critical point of extinction. Rethinking this kind of living is vital if we want to survive. Learning from nature's design evolution shows us that simplicity and modularity are methods nature applies to sustain a long life.

Figure 9.3: Cellphones designs in the late 20 and early 21 century.

Figure 9.4: Cellphones designs today.

9.4 Modular Design

A modular design is an approach for product designing which is used to produce a complete product by integrating or combining smaller parts that are independent of each other. With the modular design approach, a complex product (for example, a car) can be broken down or divided into smaller and simpler components that are independently designed and manufactured. Each of these individual components is then integrated (or assembled) together to form the final product.

As mentioned earlier, modular design (or modularity) is an approach used to design various products or applications – by breaking them down into separate or independent parts. These individual parts (for example, a laptop battery) can then be used for the same functionality in different systems or products. The creative leader chooses modular designs for their products because of their many benefits.

Figure 9.5: Kisho Kurokawa Architect and associates Nakgin Capsule Tower. 1972

2. How Does Modular Design Compare Against A Non-modular Design? As per the basic modular design definition, modular design allows one to customize, reuse, upgrade, or maintain product designs. Additionally, the modular product's independent parts follow a standard interface to fit into each other as the finished product easily. On the other hand, works with non-modular designs (for example, an electric switch or electronic products) are not easy to customize or maintain.

3. What Are Some Examples Of Modular Design Products? Modular design is commonly used in various consumer products like cars, smartphones, computers, and televisions. Other modular design examples include software engineering, software product design, and even large websites (with each webpage as an individual component). A famous example of modularity is LEGO. These plastic toys contain elements that can easily be assembled and reused to develop different finished products.

4. What Are Some Of The Benefits Of Modularity In Product Designs? The use of modularity in product design offers multiple benefits, including the following:

Easy to customize products Modular design products are easier to customize according to individual customer needs or preferences. For example, if you are looking for a smartphone with better battery life, you can easily include a high-power battery component (built by a third-party manufacturer) into your model.

Faster to market Modular products, including new products, are faster to assemble and release in the market. Each modular component is designed, manufactured, and tested separately to save time, and then assembled for the final product.

Cost efficiency The use of modularity can reduce product development and testing costs for the manufacturer, all thanks to shorter development cycles and modular components' reusability. Additionally, large manufacturers can outsource various components to smaller manufacturing firms, thus cutting down their costs.

Sustainability A modular design architecture, by definition, uses reusable components that can be used in many similar products; this reduces wastage and adds to the overall sustainability of the product.

Allows incremental upgrades A modular system design or product can be easily upgraded (for example, for better performance of a smartphone or laptop). In non-modular products, it is harder to achieve incremental upgrades.

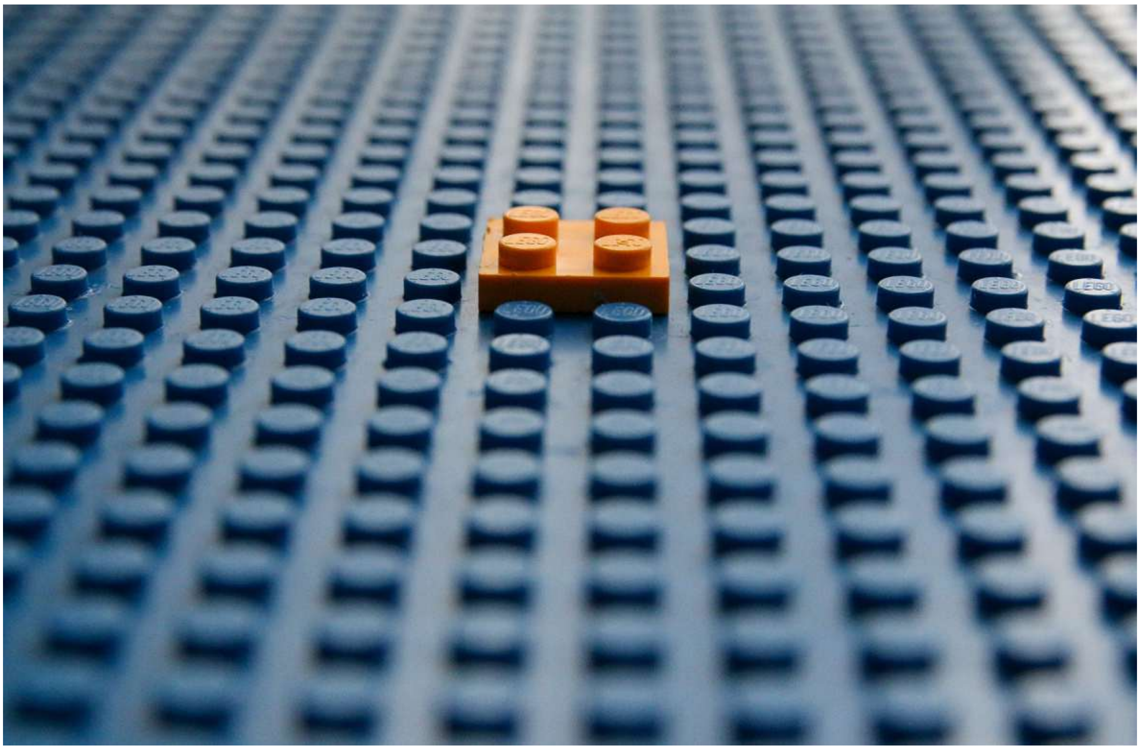
5. How Does A Modular Design Work In Software Engineering? Modular design in software engineering works through a modular programming technique that separates the overall functionality of any software product into independent and interchangeable software modules. Each module can be programmed separately and is designed to achieve specific functionality.

Through modular designs, large and complex projects can be broken down into smaller and manageable parts – that can be individually developed and integrated into the final product.

6. How Does The Modularity Approach Work In Product Designing? Many product manufacturing companies face the challenge of providing multiple varieties of the same product to meet different customer needs. This is particularly relevant in customer-centric industries like automobiles, computers, furniture, and personal devices. The use of modularity (or modular design) in product design has increased in these sectors because it helps reduce product complexity and manufacturing costs.

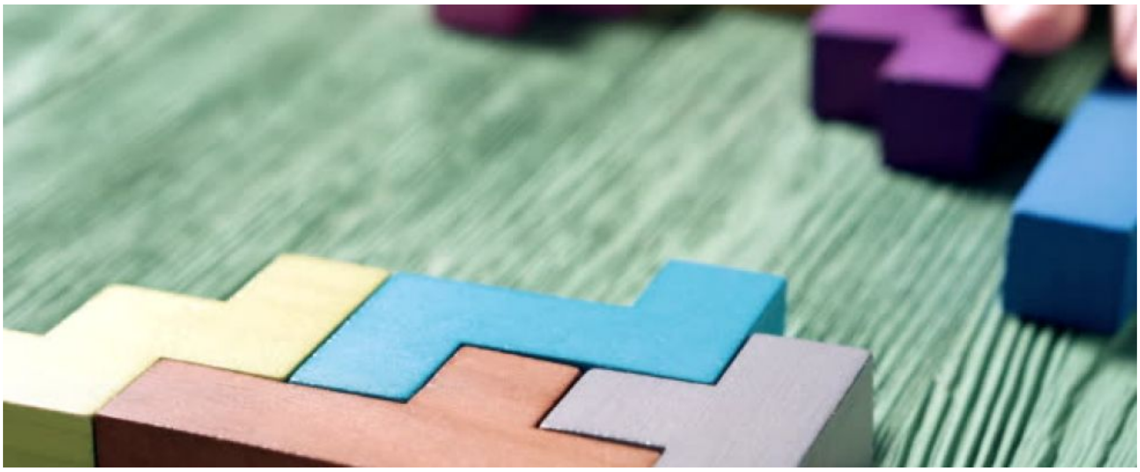
Each finished product – with modular product design – is divided into many modules, each with independent features and functionalities.

With such a modular architecture, changing one (or more) modules does not impact the other modules' functionality.



Make it Modular

Make it Personal



9.5 Modular Design Process

Earlier in the design process, by trying to make the building sustainable, the modularity concept took shape. The next challenge was to find a way to make the house Modular. Trying different approaches by dividing the floor into individual profiles that can connect like Lego parts and make customized Houses with diverse functions based on the owner's need in the upcoming images, the process of finding a proper way to divide the floor is visualized. The goal is to bring the most flexibility for the owners to decide between different parts and functions.The building can customize itself and acclimate to the owner's lifestyle and the environment.

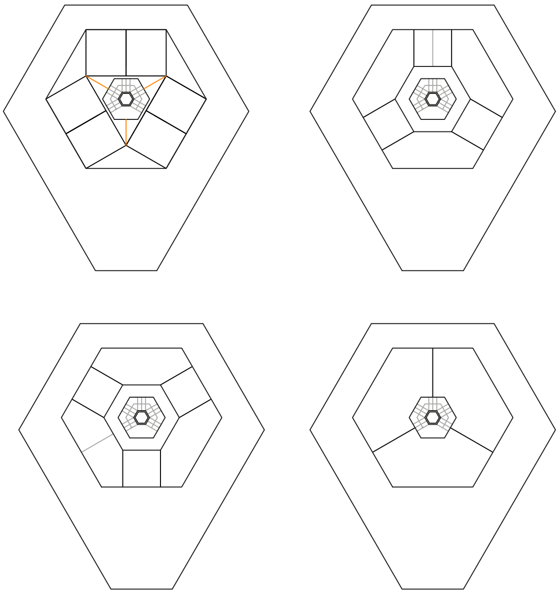


Figure 9.7: Various geometry approaches to make the Project Modular.(Rhino)

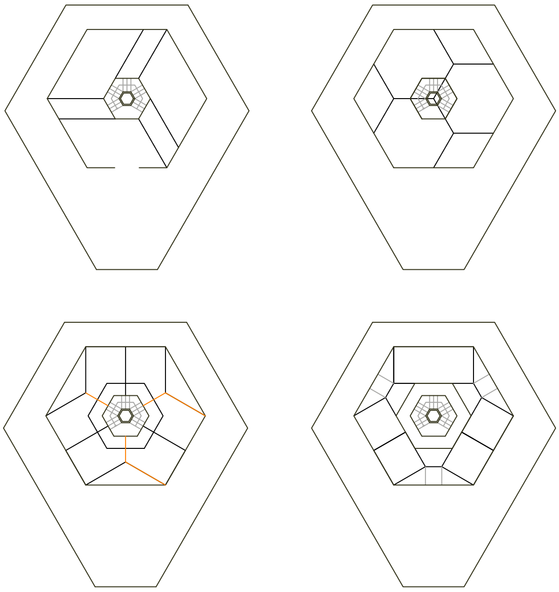


Figure 9.6: Various geometry approaches to make the Project Modular.(Rhino)

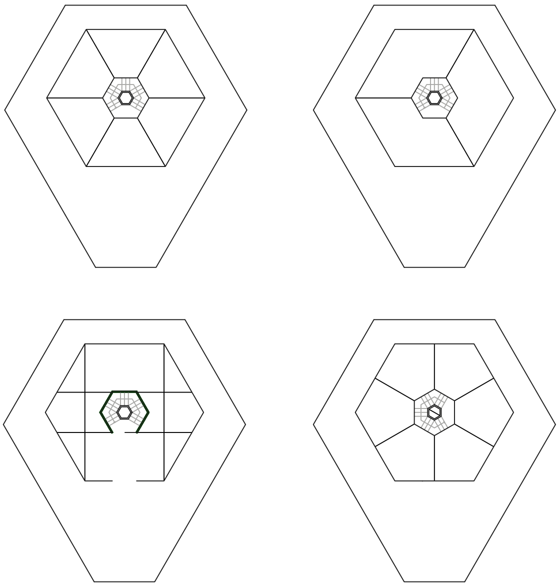


Figure 9.8: Various geometry approaches to make the Project Modular.(Rhino)

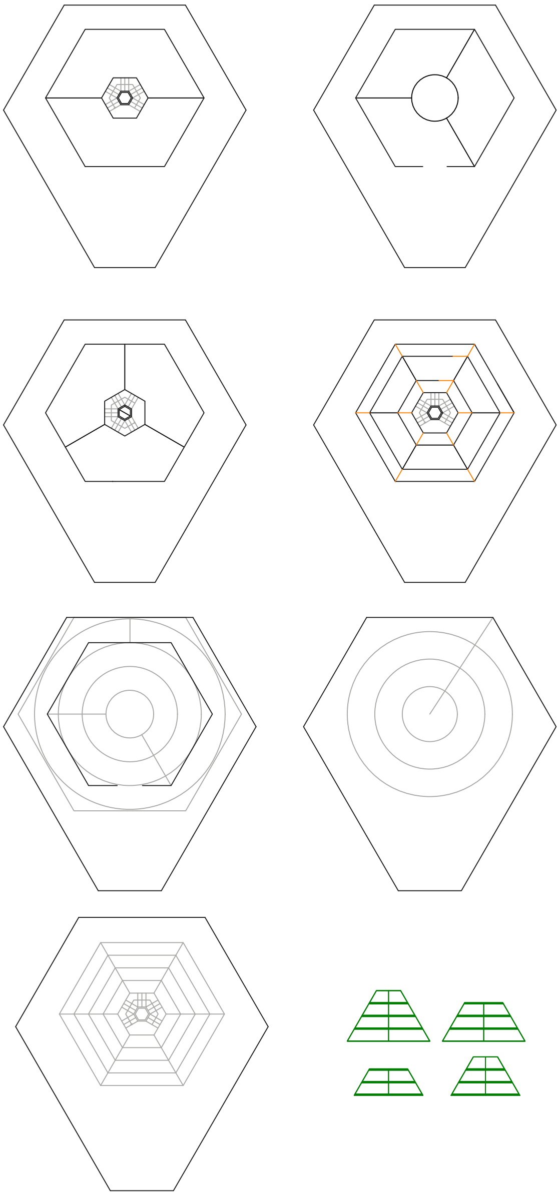


Figure 9.9: Terappazoid is selected as the most propper geometry.(Rhino)

After examining different geometry variations from triangle to hexagonal, the most convenient and practical geometry for this goal (based on my taste) was a trapezoid. Based on the hexagonal project shell, the trapezoid provides a dynamic and flexible possibility and divides the floor into six sections. For a duplex building, it offers twelve pieces to choose from for various functions.

These trapezoids could be divided into four parts to bring more design flexibility and work as a linear guide. It offers the designers specific components for a corridor or, for example, a bridge on top of the lower floor.

In addition to trapezoid division, a radial division applies more flexibility to the project. It divides These trapezoids into four regions to bring more design flexibility and work as a linear guide. It offers specific components to architects for designing a corridor or, for example, a bridge on top of the lower floor. The following images propose examples for placing the rooms and using the trapezoid-radial sections.

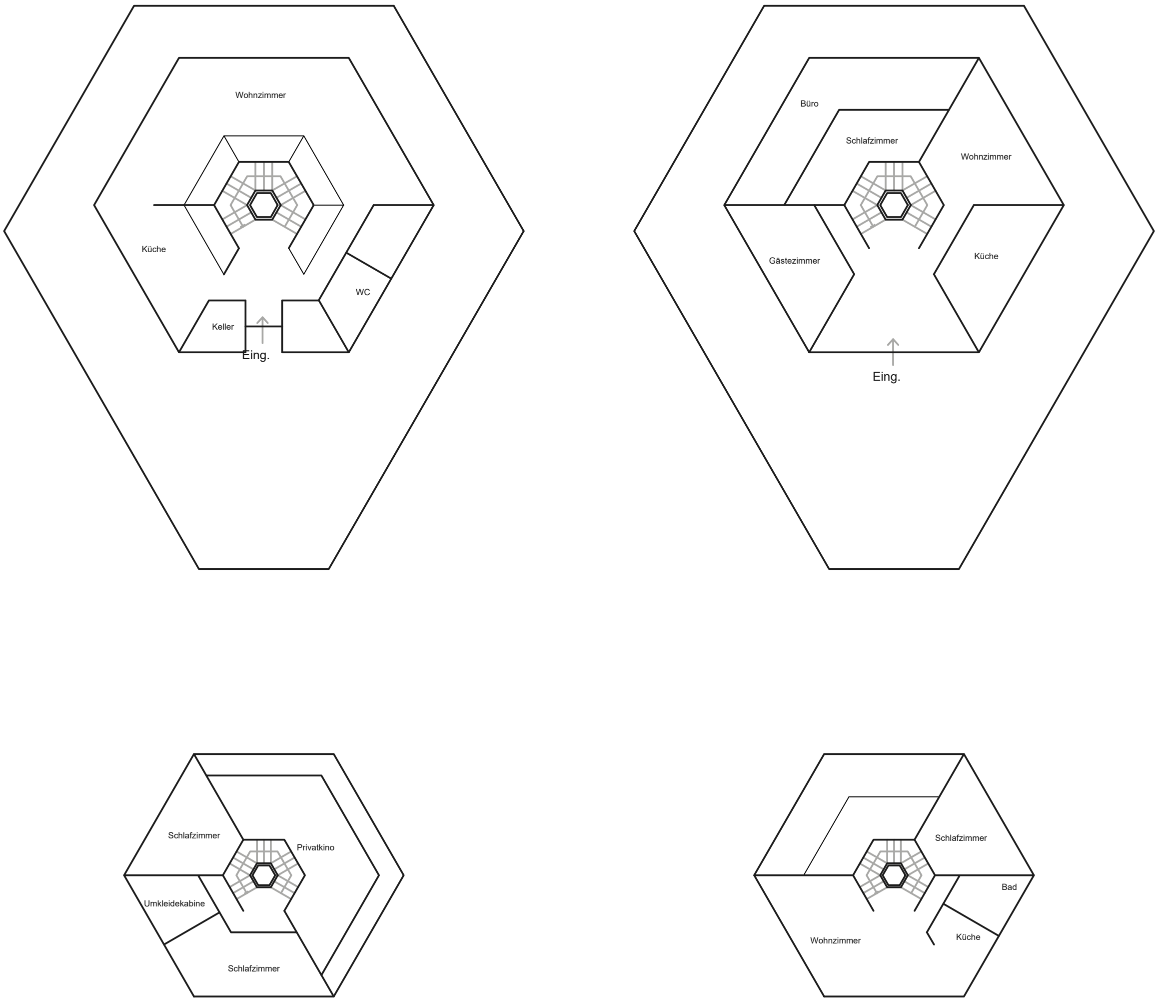


Figure 9.10: Testing if Terapazoid geometry provides enough possibilities for a functional house(Autocad)

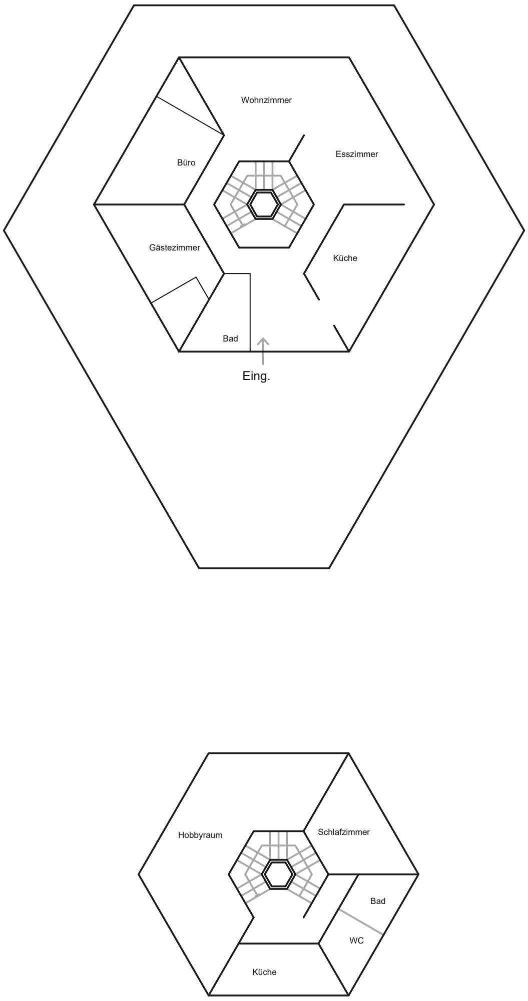


Figure 9.11: Testing if Terapazoid geometry provides enough possibilities for a functional house(Autocad)

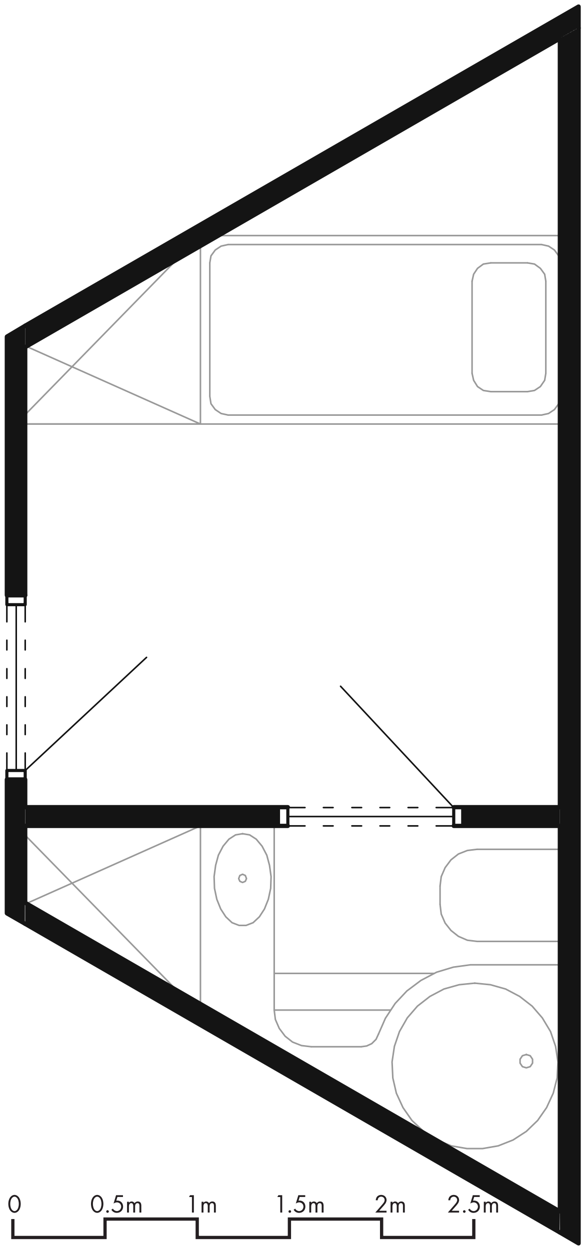


Figure 9.12: Bedroom Variation1(Revit)

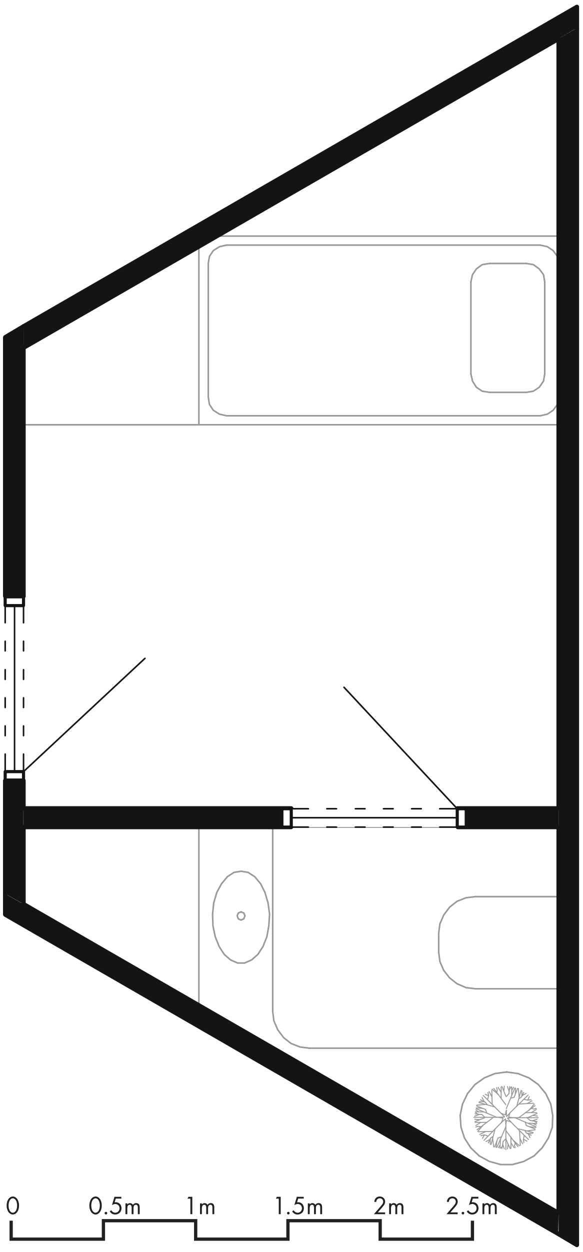


Figure 9.13: Bedroom Variation2(Revit)

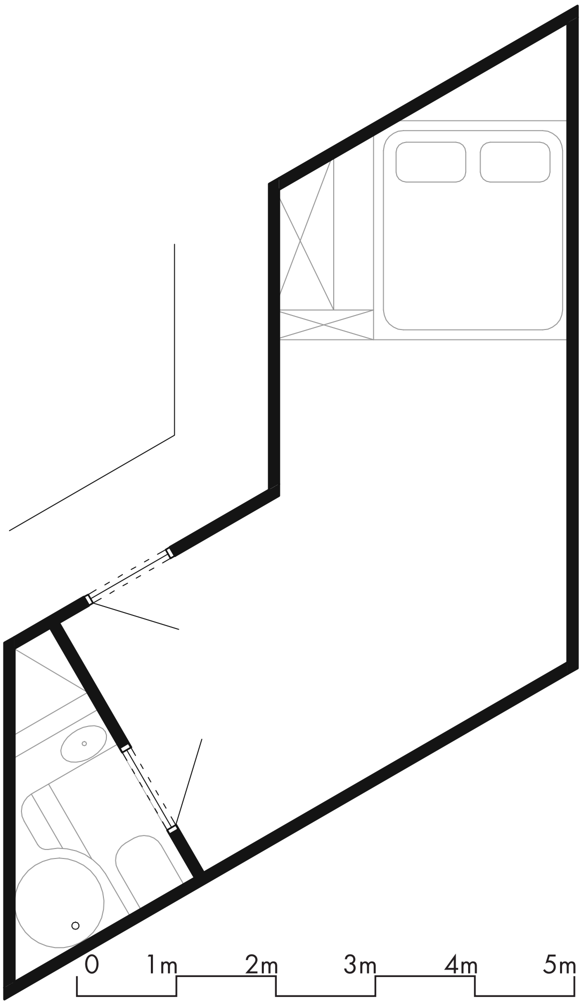


Figure 9.14: Bedroom Variation3(Revit)

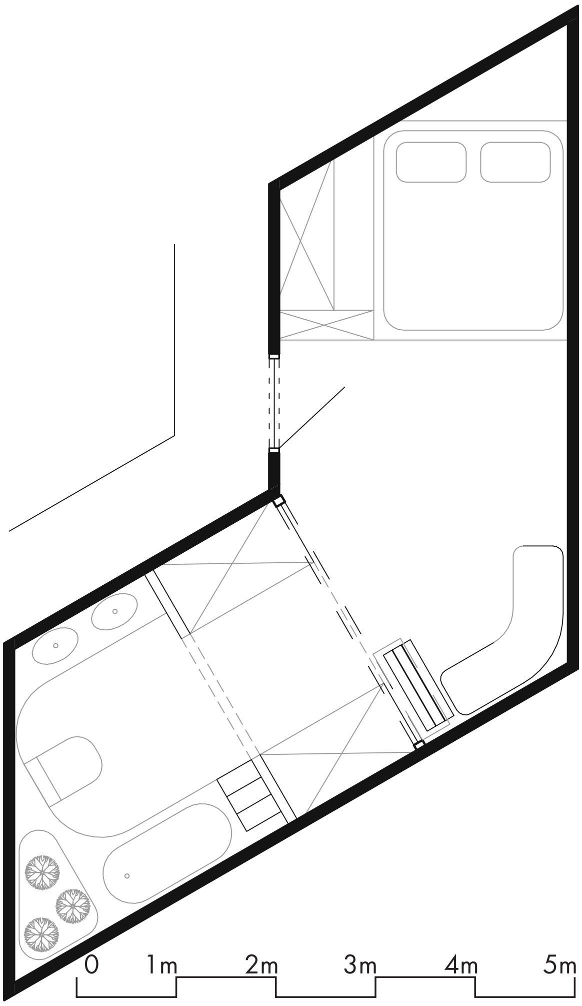


Figure 9.15: Bedroom Variation4(Revit)

The sky is the limit. As shown in the previous images, tetraploids could attach and make larger or smaller rooms, functioning separately or as a combination, providing a vast opportunity for the owners to choose and customize their preferable houses. One needs a large living room, and the other likes to cook and have more real estate in their kitchen. A Master bedroom with a walking closet or its own office to work and spend more time in, or a small room just for sleeping? A small bathroom for a quick shower or soothing in a bathtub looking outside the window surrounded by ocean water and sea life?

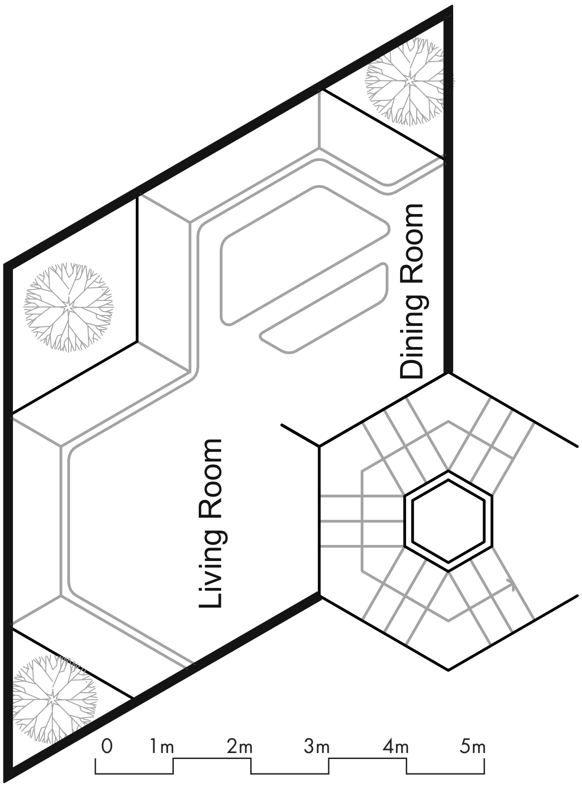


Figure 9.16: Living/Dining Room 3(Revit)

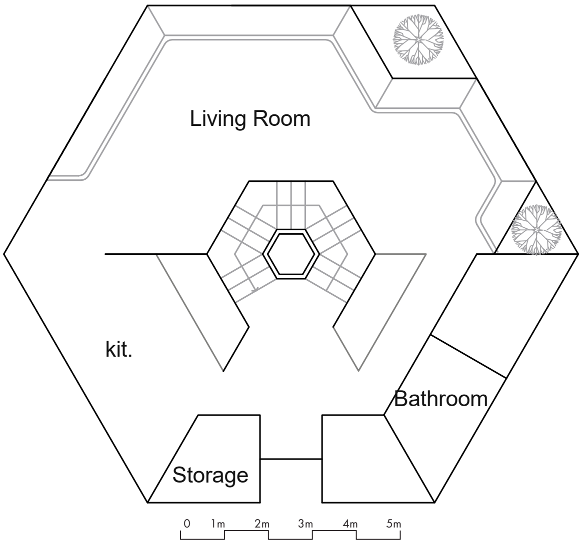


Figure 9.17: GF Modular

A large living room to spend more time with family and friends or a cozy dining room for the ones who love cooking and socializing around the dining table?
The owner can decide and choose.

10 Plans and Details

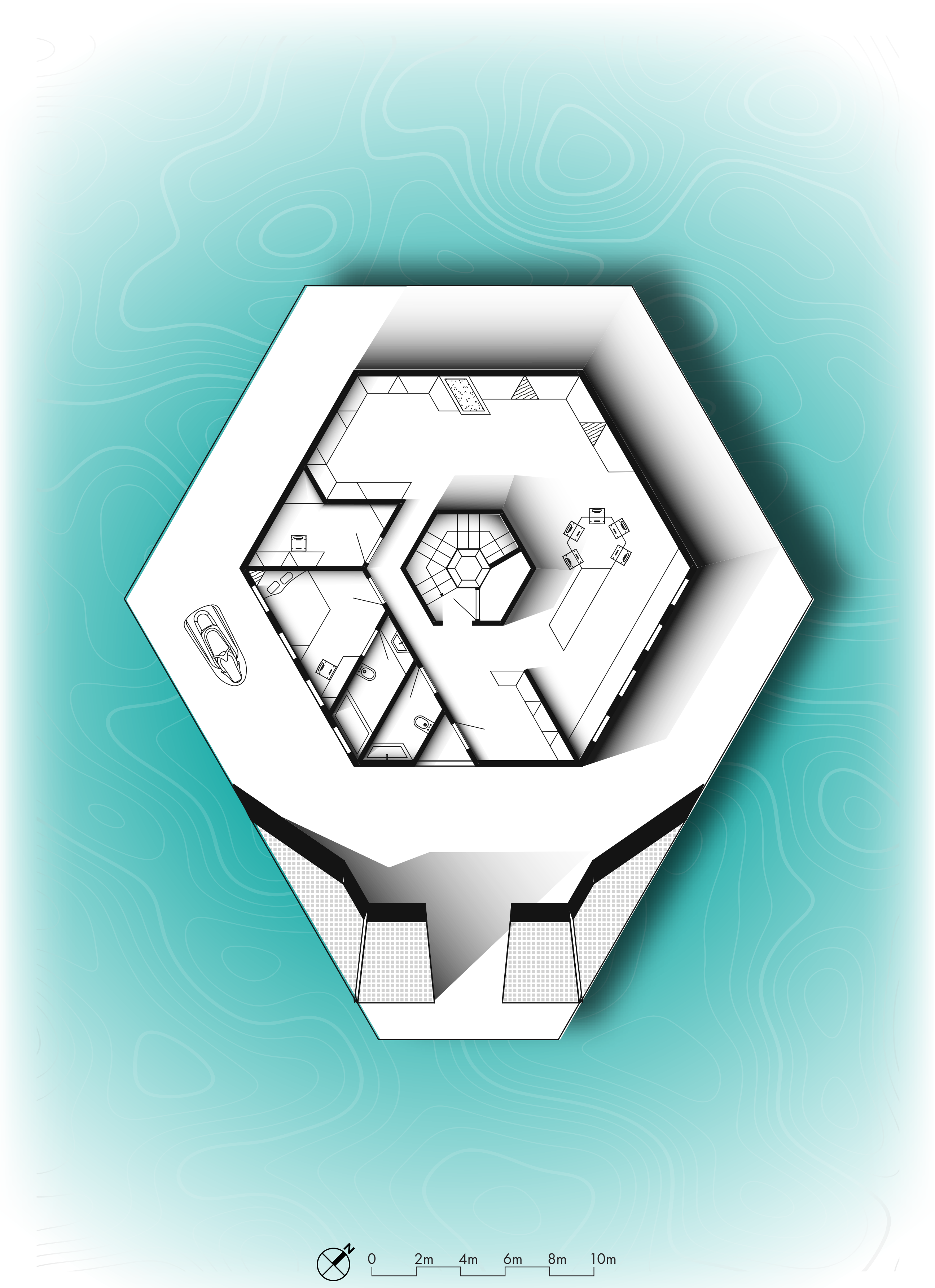


Figure 10.1: GF Modular Variation1 SC:1/200

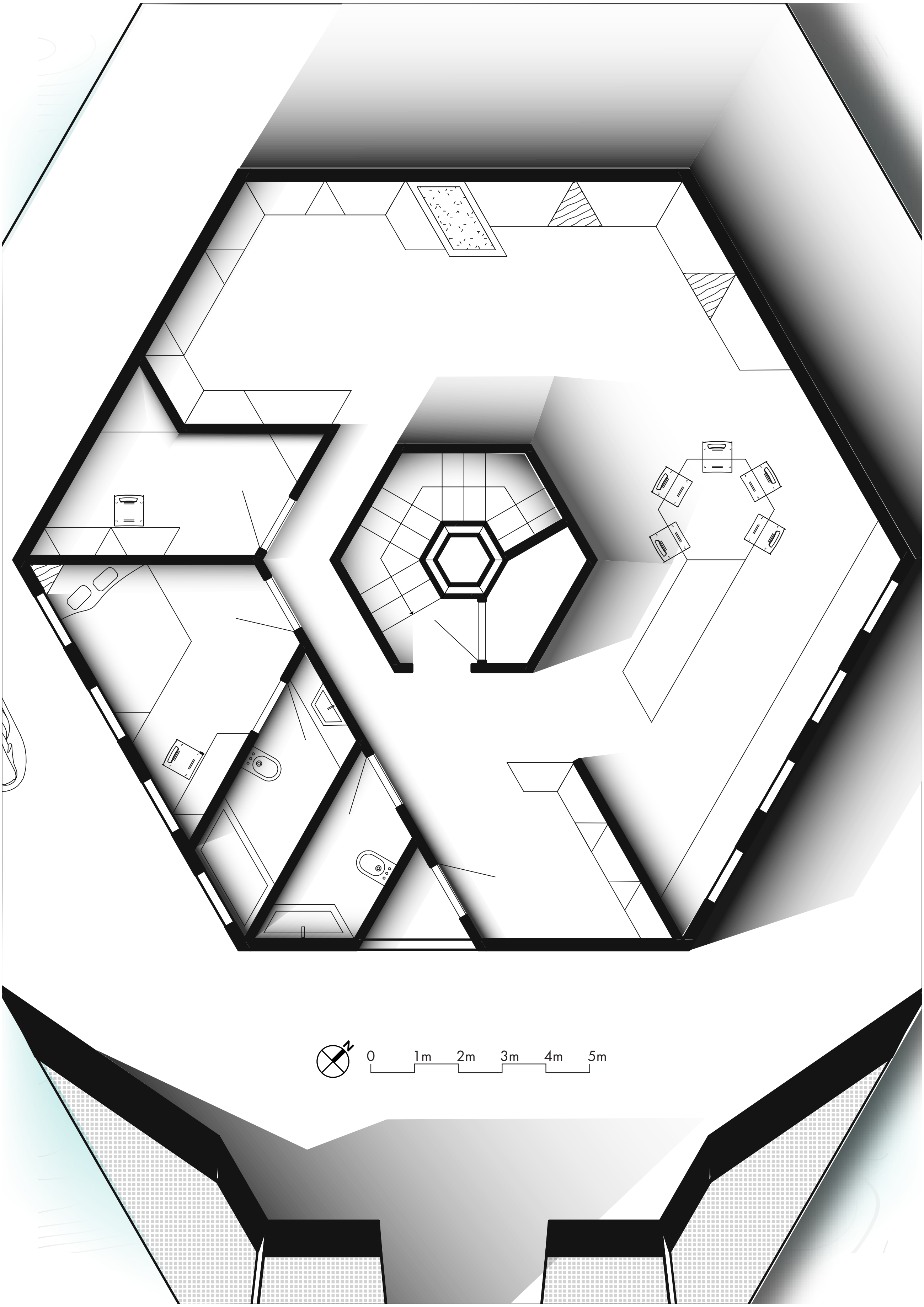


Figure 10.2: GF Modular Variation1 SC:1/100

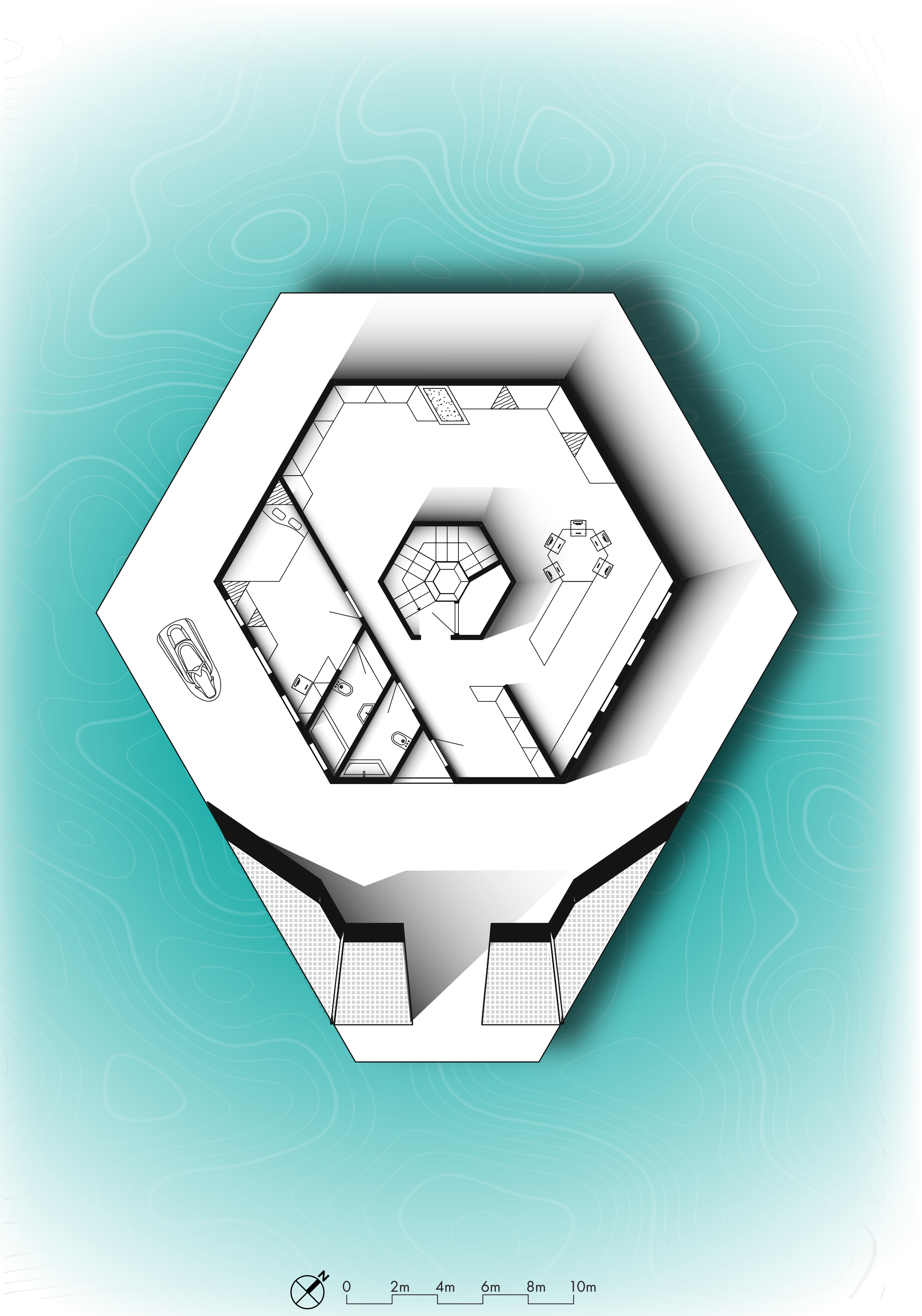


Figure 10.3: GF Modular Variation2 SC:1/200

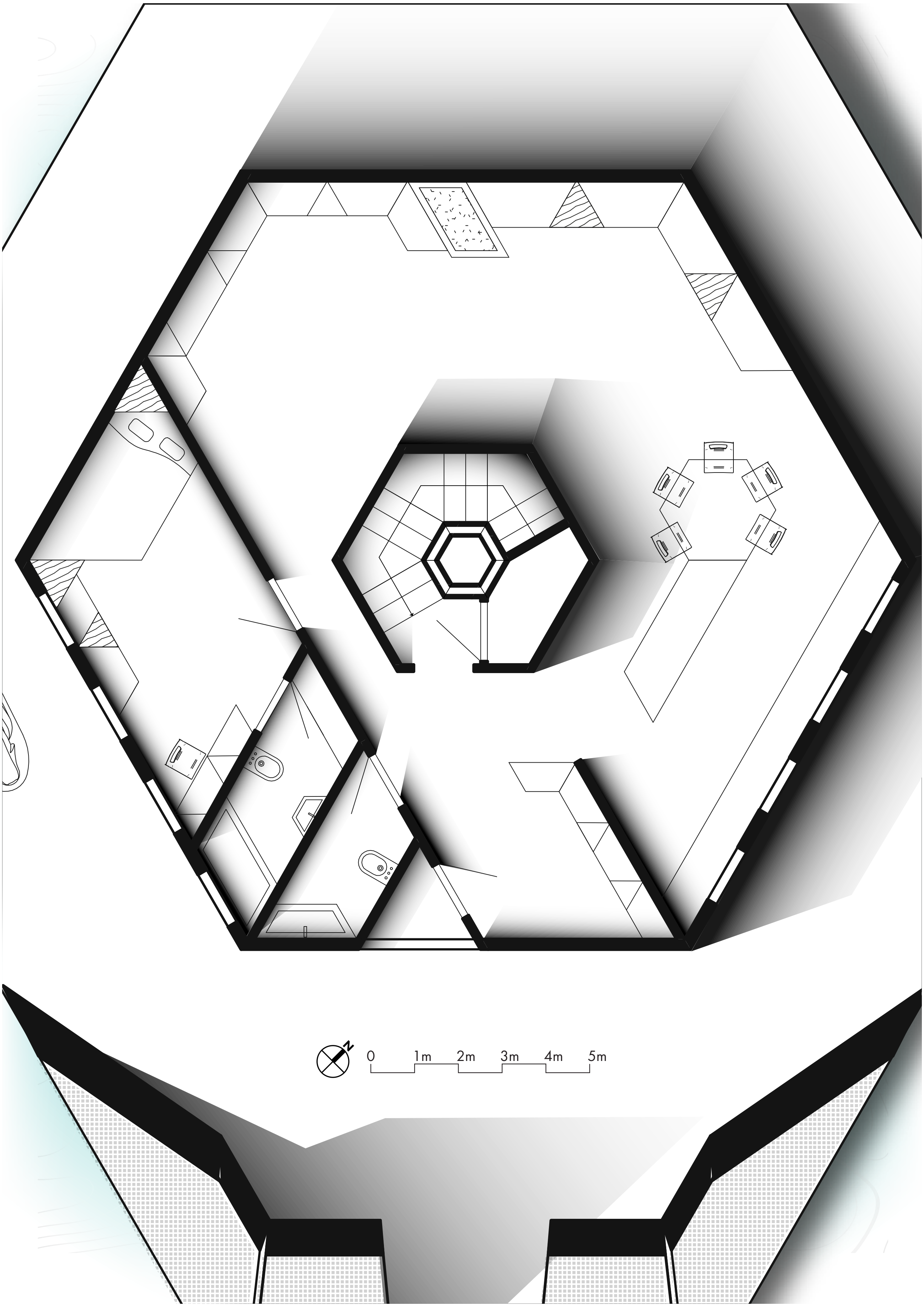


Figure 10.4: GF Modular SC:1/100

Figure 10.5: UG Modular SC:1/200

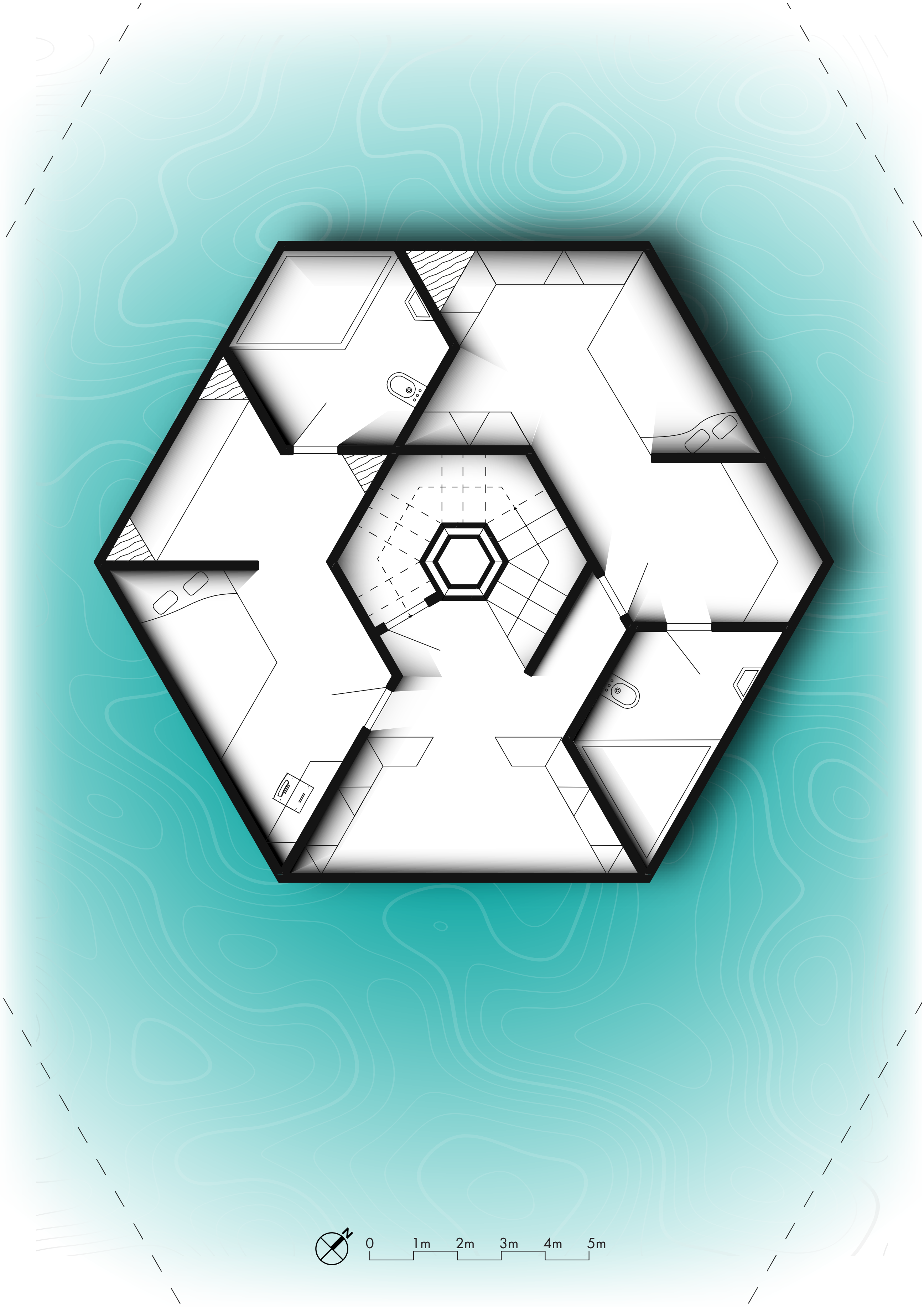


Figure 10.6: UG Modular Variation2 SC:1/100

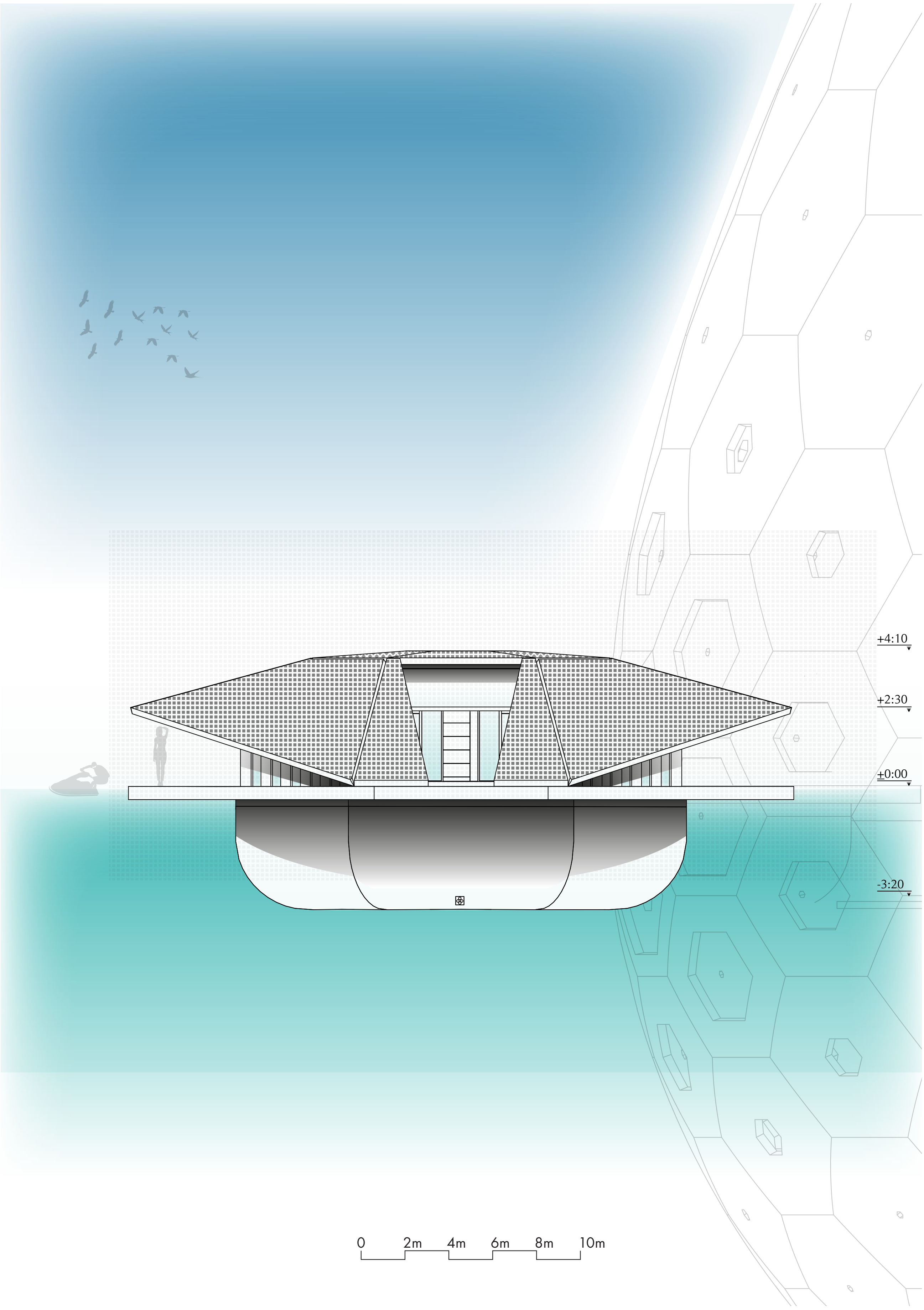


Figure 10.7: Front Elevation SC:1/200

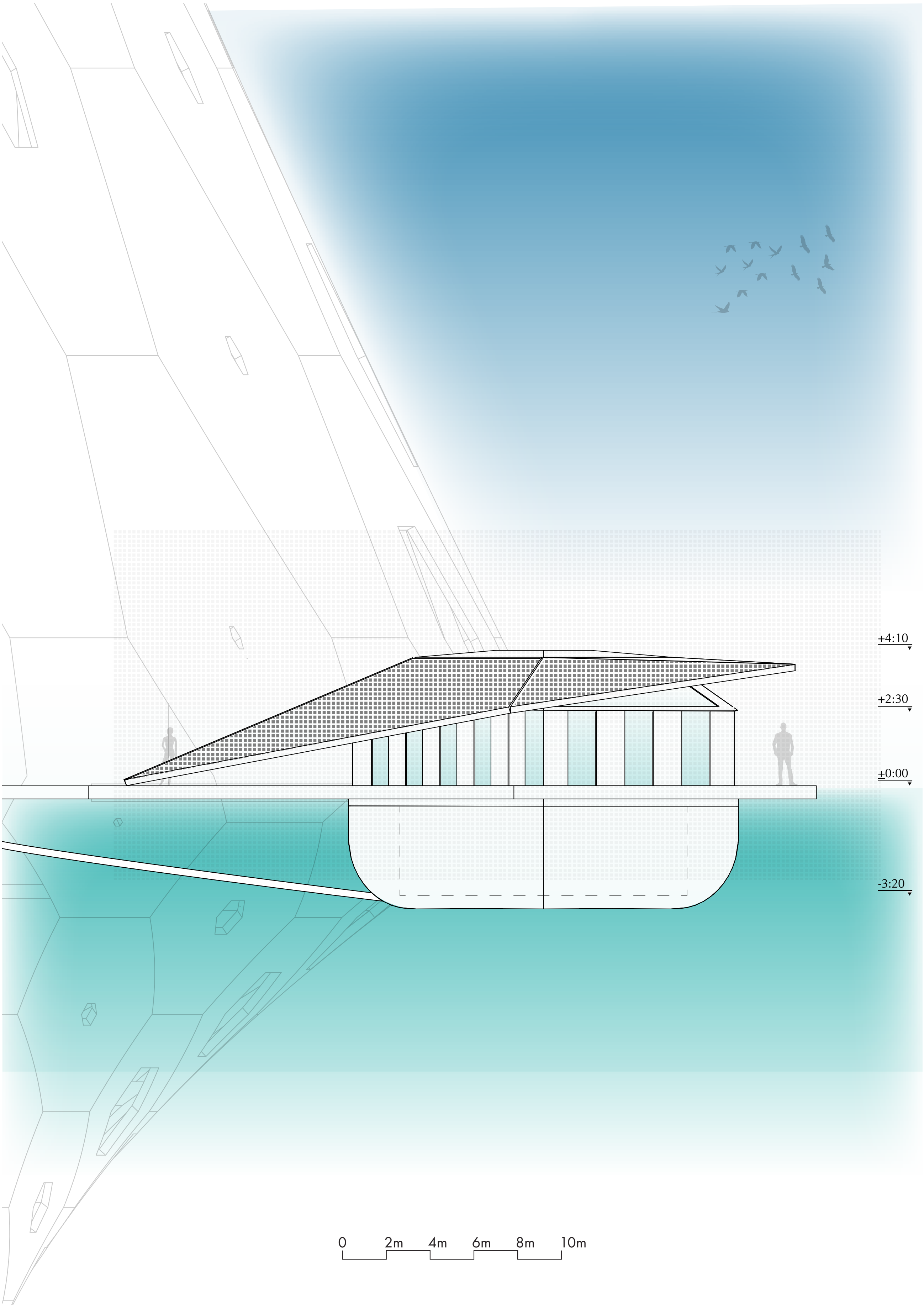


Figure 10.8: Side Elevation-2 SC:1/200

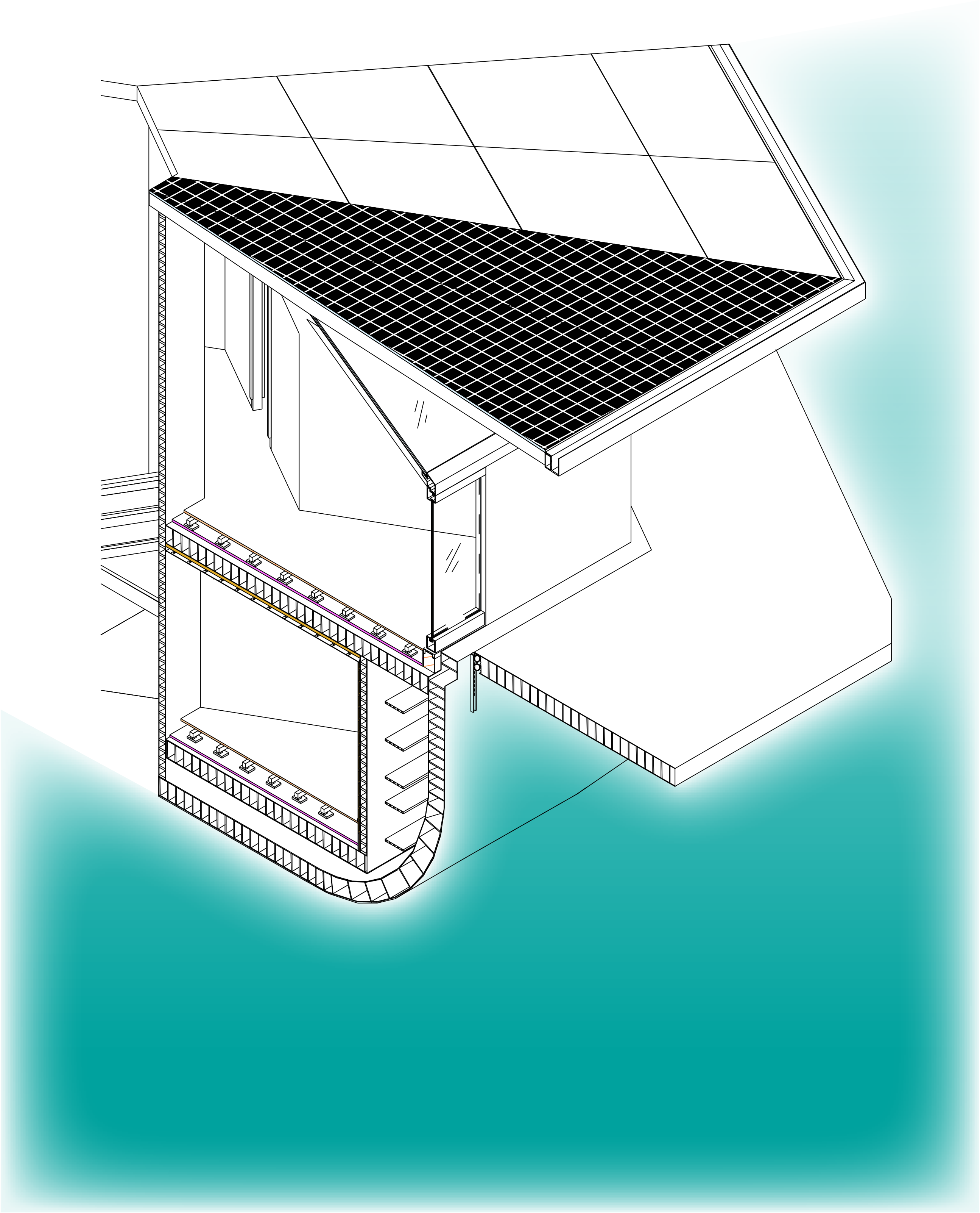


Figure 10.9: Facade Cut-3D

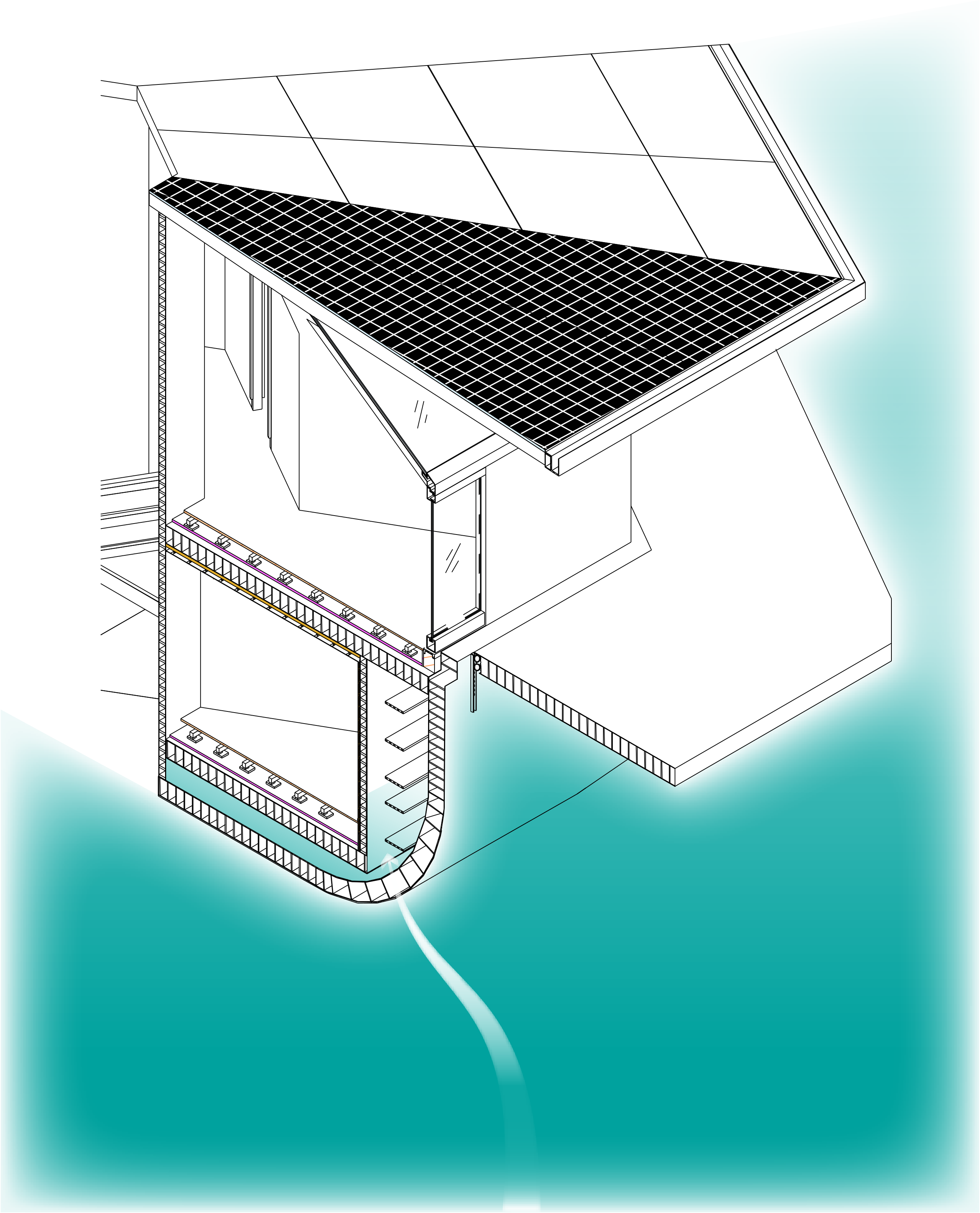


Figure 10.10: Facade Cut-3D Balast thank is filled with water

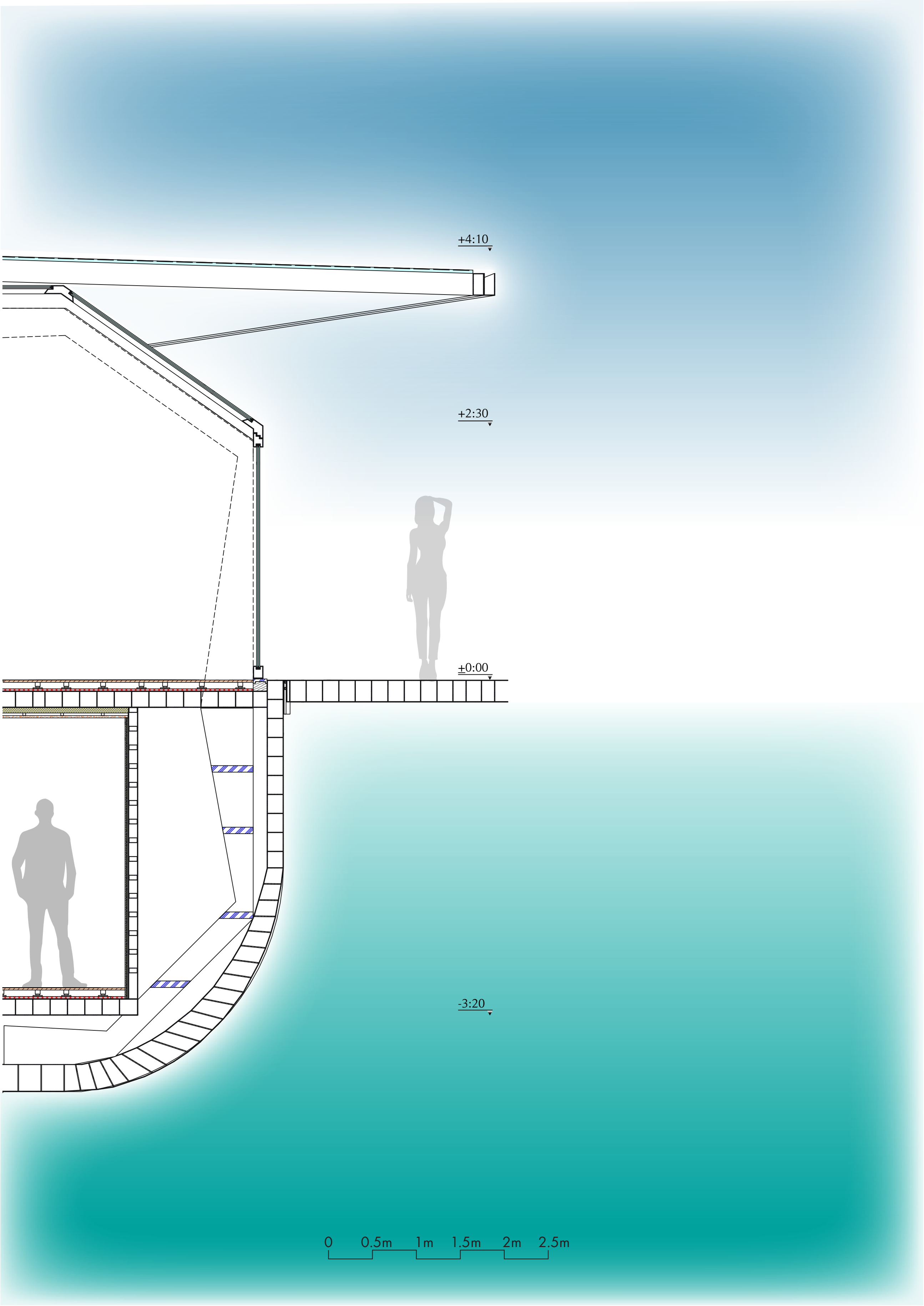


Figure 10.11: Facade Cut-2D SC:1/50

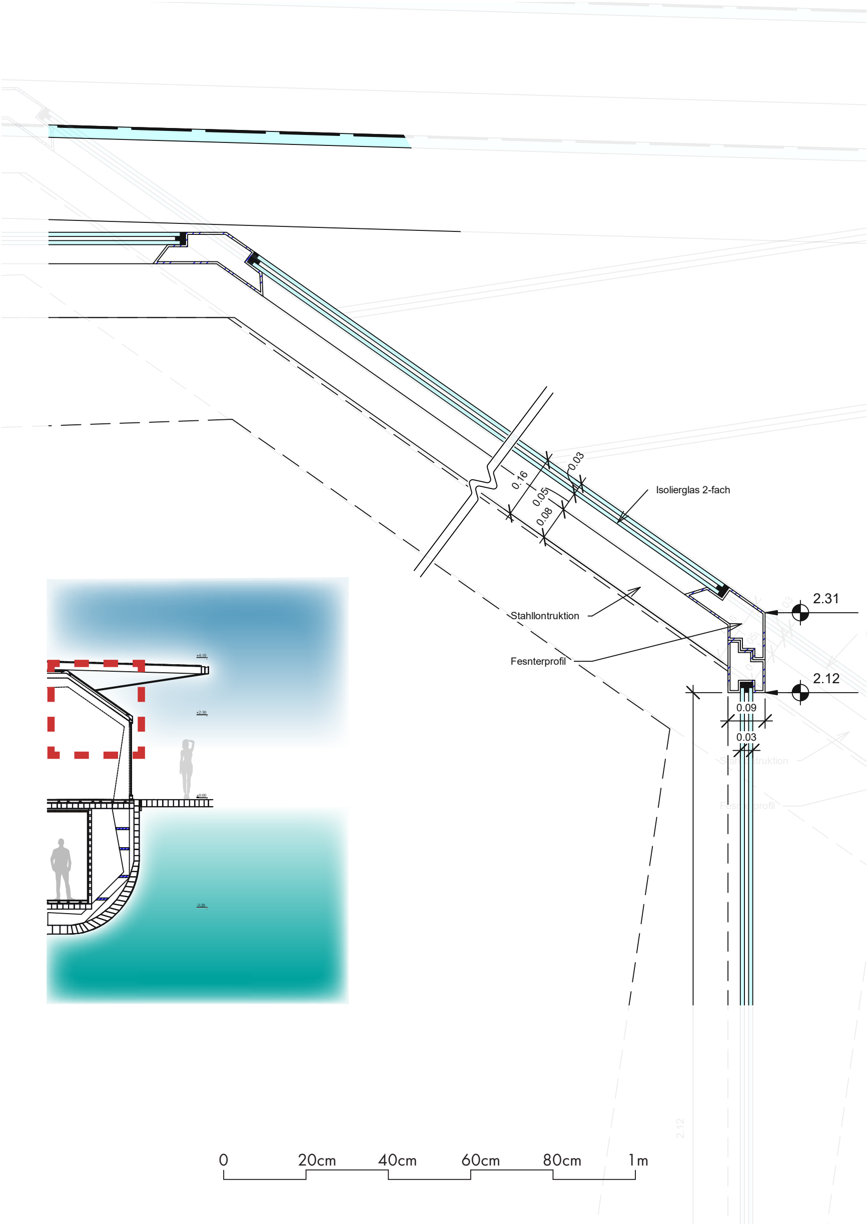


Figure 10.12: Details SC:1/20

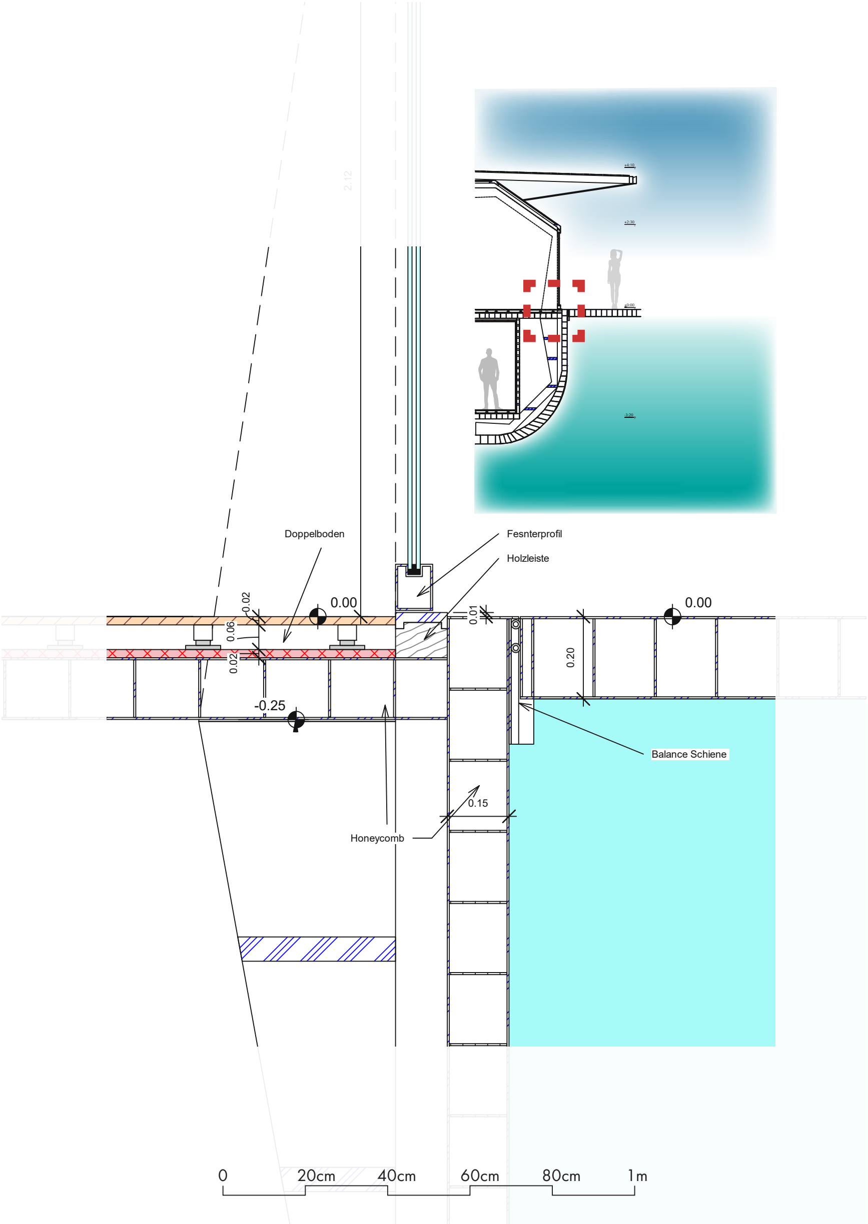


Figure 10.13: Details SC:1/20

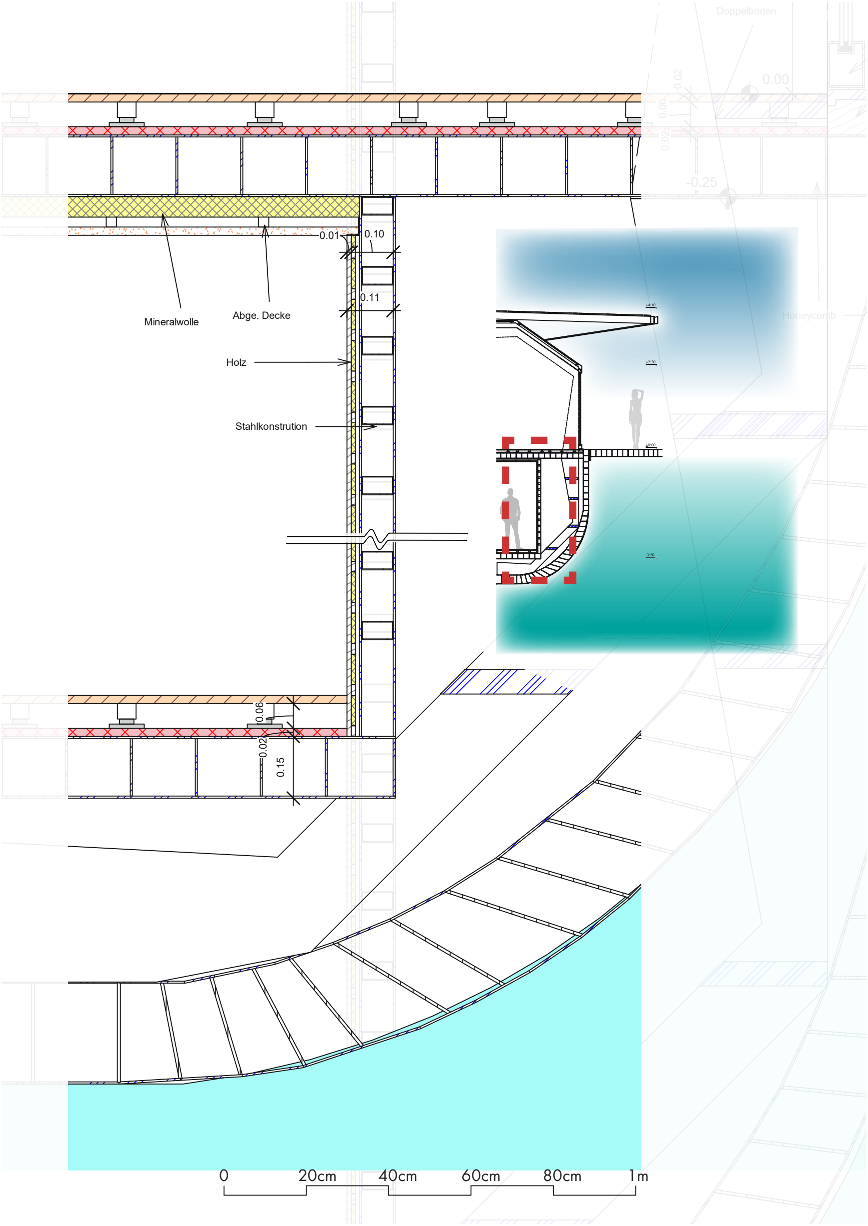


Figure 10.14: Details SC:1/20

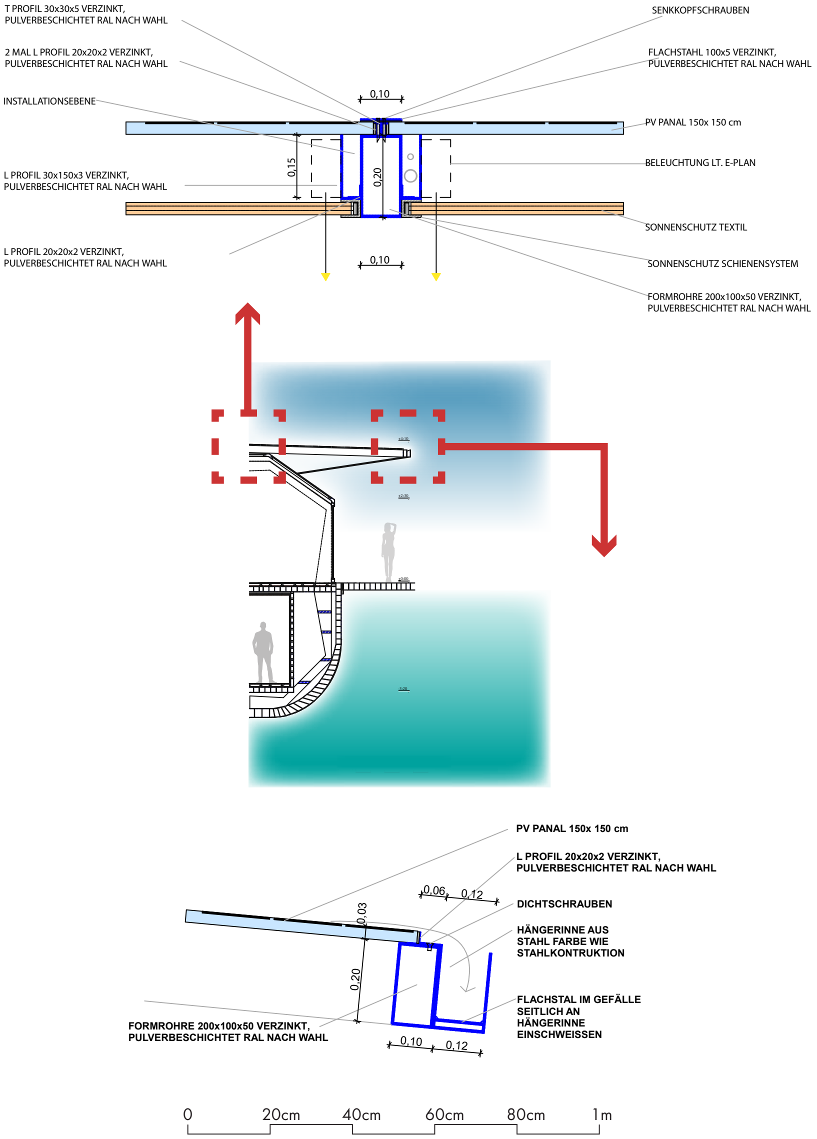


Figure 10.15: Details SC:1/20

11 Infrastructure

Reaching the final stages of designing floating Houses, the need for infrastructure that provides more reassurance for the whole project becomes more significant. Although the project is meant to be off the grid, there will be a need for wastewater management and supplying the project necessities. For that matter, the concept of connecting the houses seems reasonable. as it delivers more surface to the whole project. More surface on the water means more comfort for residents as it reduces the wave shocks under the buildings. The outcome would be more stability and comfort. The infrastructure needs to be connected to the earth and provide clean water and a wastewater management program.

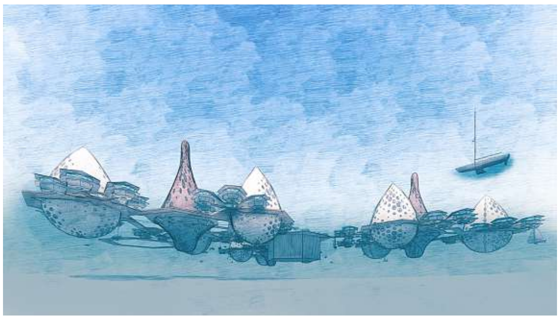


Figure 11.1: Support Base (Rhino-Lumion)

This support base can also provide electricity and energy for the houses if there is a lack of energy. At the same time, it collects energy from homes on the days they produce more electrical power than they need with the Photovoltaic panels.

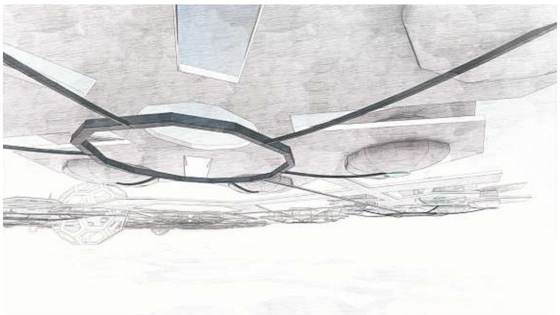


Figure 11.2: Energy and Waste water management(Rhino-Lumion)

Underneath the house's platform, a mechanism delivers the energy and wastewater, and vice versa receives energy and fresh water from the base.

11.1 House to District to City

Realizing the floating-bases concept needs a precise solution to reduce the design barriers the floating houses face, as they need to connect to a floating base. Arrange the Modular dwellings so that they receive the same and fair amount of benefits the Floating-base provides, mainly when the Floating-Base develops and there is a need for more space and new houses. Finding a solution for this issue redirected the project to comprehend strategies nature uses to evolve after each life cycle in its evolution path. The method I decided to use for an infinite expansion potential of the Floating-Base, is a Fractal.

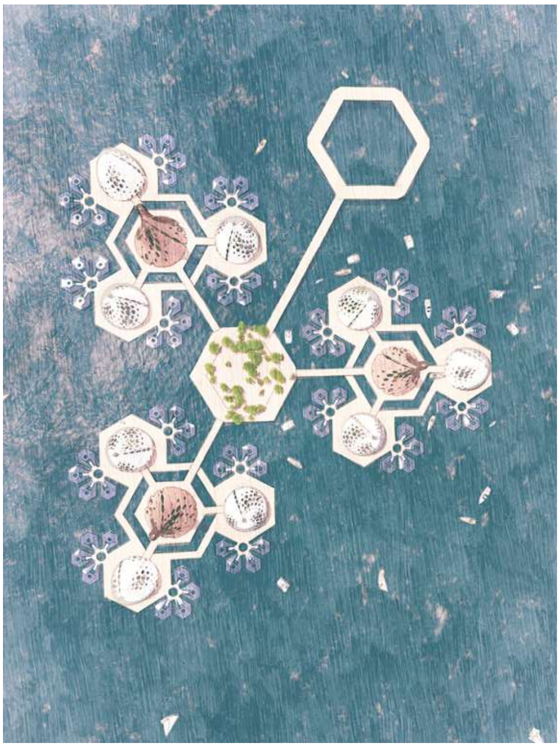


Figure 11.3: Floating district(Rhino-Lumion)

Figure 11.4: New york 23.Feb.2187AC.(Rhino-Lumion-Photoshop)

11.2 Fractal

The term "fractal" was coined by the mathematician Benoît Mandelbrot in 1975.Mandelbrot based it on the Latin frāctus, meaning "broken" or "fractured", and used it to extend the concept of theoretical fractional dimensions to geometric patterns in nature.

Figure 11.5: Fractal patterns(Tentacle by Sabine62)

A fractal is a geometric figure in which each part has the same statistical character as the whole. It is a never-ending pattern. -They are created by repeating a simple process over and over again. -They are useful in modeling structures in which similar patterns recur at progressively smaller scales, and in describing phenomena like crystal growth, fluid turbulence, and galaxy formation. -Fractals also have applications in computer graphics and animation. In mathematics, a fractal is a geometric shape containing detailed structure at arbitrarily small scales, usually having a fractal dimension strictly exceeding the topological dimension. Many fractals appear similar at various scales, as illustrated in successive magnifications of the Mandelbrot set. This exhibition of similar patterns at increasingly smaller scales is called self-similarity, also known as expanding symmetry or unfolding symmetry; if this replication is exactly the same at every scale, as in the Menger sponge, the shape is called affine self-similar. Fractal geometry lies within the mathematical branch of measure theory.

One way that fractals are different from finite geometric figures is how they scale. Doubling the edge lengths of a filled polygon multiplies its area by four, which is two (the ratio of the new to the old side length) raised to the power of two (the conventional dimension of the filled polygon). Likewise, if the radius of a filled sphere is doubled, its volume scales by eight, which is two (the ratio of the new to the old radius) to the power of three (the conventional dimension of the filled sphere). However, if a fractal's one-dimensional lengths are all doubled, the spatial content of the fractal scales by a power that is not necessarily an integer and is in general greater than its conventional dimension. This power is called the fractal dimension of the geometric object, to distinguish it from the conventional dimension (which is formally called the topological dimension).

Figure 11.6: Fractal patterns in Nature(publick domain)

Analytically, many fractals are nowhere differentiable. An infinite fractal curve can be conceived of as winding through space differently from an ordinary line – although it is still topologically 1-dimensional, its fractal dimension indicates that it locally fills space more efficiently than an ordinary line.

Sierpinski carpet (to level 6), a fractal with a topological dimension of 1 and a Hausdorff dimension of 1.893

A line segment is similar to a proper part of itself, but hardly a fractal. Starting in the 17th century with notions of recursion, fractals have moved through increasingly rigorous mathematical treatment to the study of continuous but not differentiable functions in the 19th century by the seminal work of Bernard Bolzano, Bernhard Riemann, and Karl Weierstrass, and on to the coining of the word fractal in the 20th century with a subsequent burgeoning of interest in fractals and computer-based modelling in the 20th century.

There is some disagreement among mathematicians about how the concept of a fractal should be formally defined. Mandelbrot himself summarized it as “beautiful, damn hard, increasingly useful. That’s fractals.” More formally, in 1982 Mandelbrot defined fractal as follows: “A fractal is by definition a set for which the Hausdorff–Besicovitch dimension strictly exceeds the topological dimension.” Later, seeing this as too restrictive, he simplified and expanded the definition to this: “A fractal is a rough or fragmented geometric shape that can be split into parts, each of which is (at least approximately) a reduced-size copy of the whole.” Still later, Mandelbrot proposed “to use fractal without a pedantic definition, to use fractal dimension as a generic term applicable to all the variants”.

The consensus among mathematicians is that theoretical fractals are infinitely self-similar iterated and detailed mathematical constructs, of which many examples have been formulated and studied. Fractals are not limited to geometric patterns, but can also describe processes in time. Fractal patterns with various degrees of self-similarity have been rendered or studied in visual, physical, and aural media and found in nature, technology, art, architecture and law. Fractals are of particular relevance in the field of chaos theory because they show up in the geometric depictions of most chaotic processes (typically either as attractors or as boundaries between basins of attraction).

The history of fractals traces a path from chiefly theoretical studies to modern applications in computer graphics, with several notable people contributing canonical fractal forms along the way. A common theme in traditional African architecture is the use of fractal scaling, whereby small parts of the structure tend to look similar to larger parts, such as a circular village made of circular houses.[35] According to Pickover, the mathematics behind fractals began to take shape in the 17th century when the mathematician and philosopher Gottfried Leibniz pondered recursive self-similarity (although he made the mistake of thinking that only the straight line was self-similar in this sense).

In his writings, Leibniz used the term “fractional exponents”, but lamented that “Geometry” did not yet know of them. Indeed, according to various historical accounts, after that point few mathematicians tackled the issues and the work of those who did remained obscured largely because of resistance to such unfamiliar emerging concepts, which were sometimes referred to as mathematical “monsters”. Thus, it was not until two centuries had passed that on July 18, 1872 Karl Weierstrass presented the first definition of a function with a graph that would today be considered a fractal, having the non-intuitive property of being everywhere continuous but nowhere differentiable at the Royal Prussian Academy of Sciences.

In addition, the quotient difference becomes arbitrarily large as the summation index increases. Not long after that, in 1883, Georg Cantor, who attended lectures by Weierstrass, published examples of subsets of the real line known as Cantor sets, which had unusual properties and are now recognized as fractals.[8]:11–24 Also in the last part of that century, Felix Klein and Henri Poincaré introduced a category of fractal that has come to be called “self-inverse” fractals.

A Sierpinski gasket can be generated by a fractal tree. One of the next milestones came in 1904, when Helge von Koch, extending ideas of Poincaré and dissatisfied with Weierstrass’s abstract and analytic definition, gave a more geometric definition including hand-drawn images of a similar function, which is now called the Koch snowflake. Another milestone came a decade later in 1915, when Wacław Sierpiński constructed his famous triangle then, one year later, his carpet. By 1918, two French mathematicians, Pierre Fatou and Gaston Julia, though working independently, arrived essentially simultaneously at results describing what is now seen as fractal behaviour associated with mapping complex numbers and iterative functions and leading to further ideas about attractors and repellors (i.e., points that attract or repel other points), which have become very important in the study of fractals.

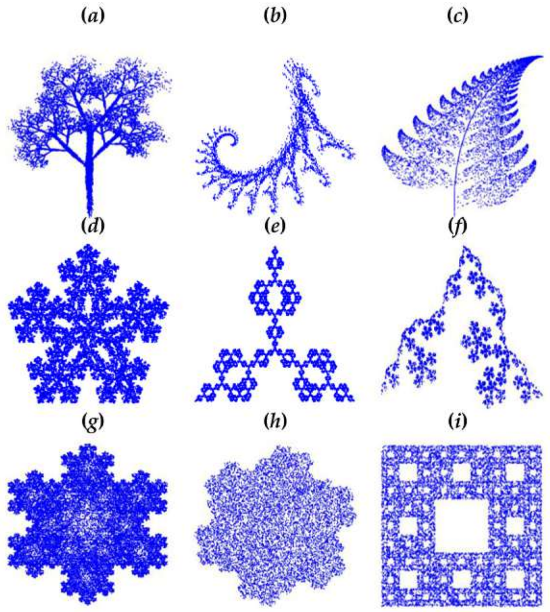


Figure 11.7: Nine point-clouds showing some well-known fractals: (a) tree; (b) seahorse; (c) fern leaf; (d–h) snowflakes; (i) the Sierpinski Carpet.[1]

Very shortly after that work was submitted, by March 1918, Felix Hausdorff expanded the definition of "dimension", significantly for the evolution of the definition of fractals, to allow for sets to have non-integer dimensions. The idea of self-similar curves was taken further by Paul Lévy, who, in his 1938 paper Plane or Space Curves and Surfaces Consisting of Parts Similar to the Whole, described a new fractal curve, the Lévy C curve.A strange attractor that exhibits multifractal scaling Uniform mass center triangle fractal 2x 120 degrees recursive IFS Different researchers have postulated that without the aid of modern computer graphics, early investigators were limited to what they could depict in manual drawings, so lacked the means to visualize the beauty and appreciate some of the implications of many of the patterns they had discovered (the Julia set, for instance, could only be visualized through a few iterations as very simple drawings). That changed, however, in the 1960s, when Benoit Mandelbrot started writing about self-similarity in papers such as How Long Is the Coast of Britain? Statistical Self-Similarity and Fractional Dimension, which built on earlier work by Lewis Fry Richardson. In 1975 Mandelbrot solidified hundreds of years of thought and mathematical development in coining the word "fractal" and illustrated his mathematical definition with striking computer-constructed visualizations. These images, such as of his canonical Mandelbrot set, captured the popular imagination; many of them were based on recursion, leading to the popular meaning of the term "fractal".

11.2.1 Lindenmayer System

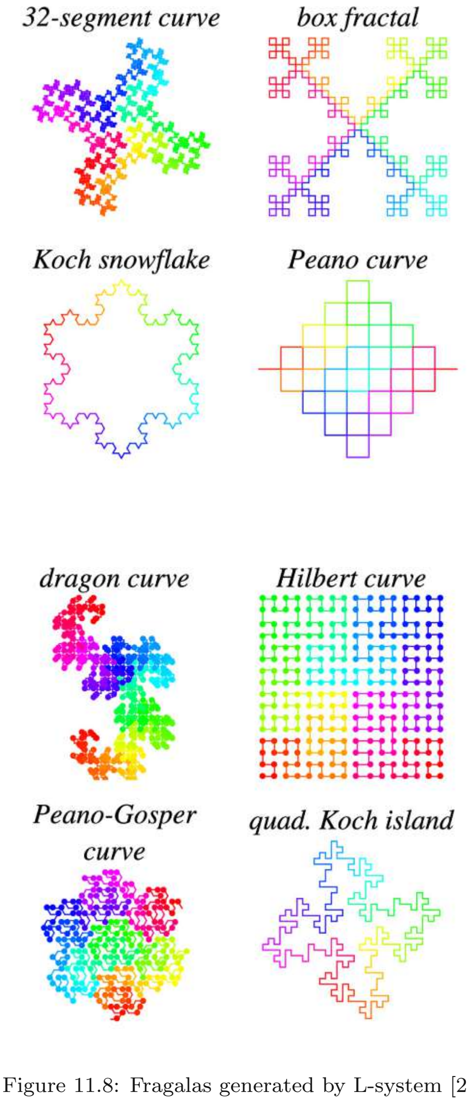
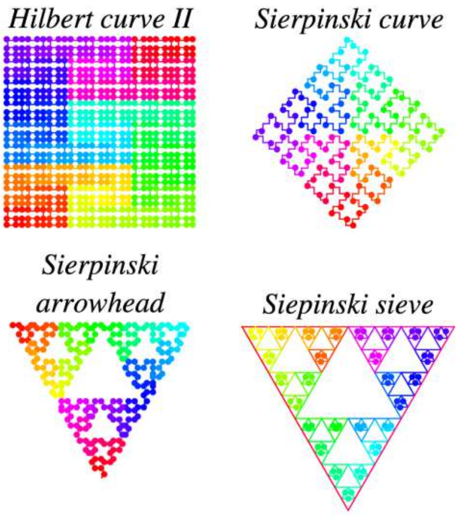


Figure 11.8: Fragalas generated by L-system [22]



11.9: Fragalas generated by L-system [22]

A Lindenmayer system, also known as an L-system, is a string rewriting system that can be used to generate fractals with dimension between 1 and 2. Several example fractals generated using Lindenmayer systems are illustrated above.[22]

11.2.2 Koch Snowflake

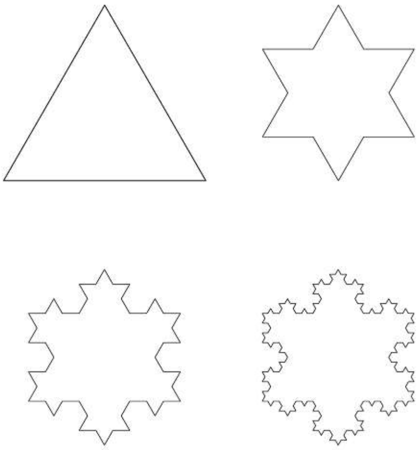


Figure 11.10: Koch Snowflake[21]

The Koch snowflake is a fractal curve, also known as the Koch island, which was first described by Helge von Koch in 1904. It is built by starting with an equilateral triangle, removing the inner third of each side, building another equilateral triangle at the location where the side was removed, and then repeating the process indefinitely. The Koch snowflake can be simply encoded as a Lindenmayer system with initial string ”F–F–F”, string rewriting rule ”F” to ”F+F–F+F”, and angle 60 degrees. The zeroth through third iterations of the construction are shown above.

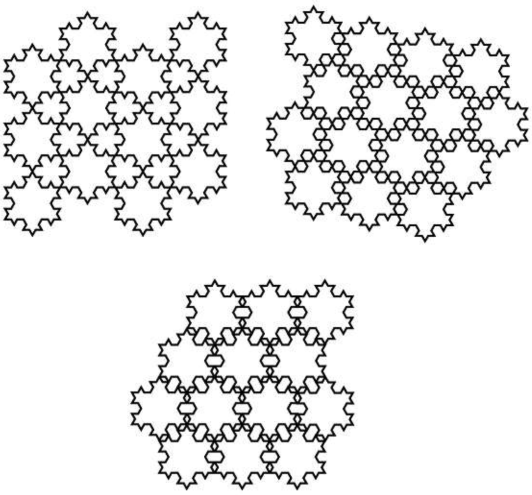


Figure 11.11: Koch Snowflake[21]

Some beautiful tilings, a few examples of which are illustrated above, can be made with iterations toward Koch snowflakes.[21]

11.2.3 Sierpiński Triangle

The Sierpiński triangle (sometimes spelled Sierpinski), also called the Sierpiński gasket or Sierpiński sieve, is a fractal attractive fixed set with the overall shape of an equilateral triangle, subdivided recursively into smaller equilateral triangles. Originally constructed as a curve, this is one of the basic examples of self-similar sets—that is, it is a mathematically generated pattern that is reproducible at any magnification or reduction. It is named after the Polish mathematician Wacław Sierpiński, but appeared as a decorative pattern many centuries before the work of Sierpiński.

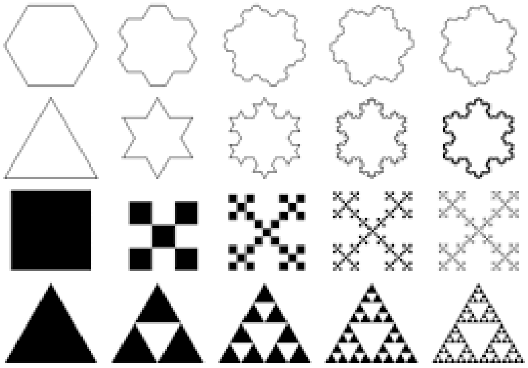


Figure 11.12: Sierpiński Triangle[20]

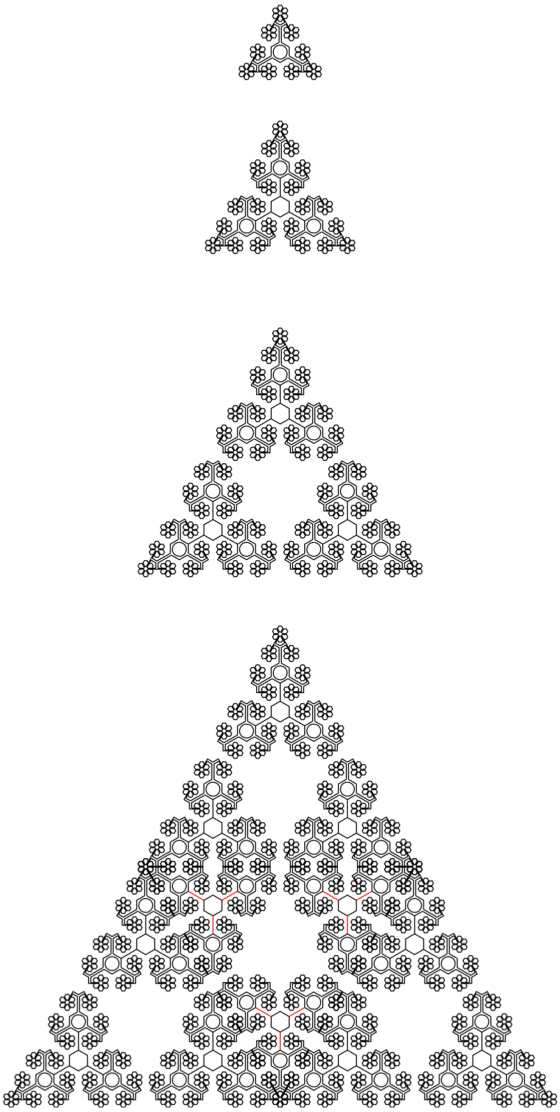


Figure 11.13: Design process of floating-Base(Autocad)

11.3 Design Process

Learning Fractal'smanner and how it works helped the project evolve in a new direction. Understanding Lindenmayer System helped the design to become more rational.

The design achieved a compelling geometry by placing the hexagonal houses around each other using Sierpinski Triangle and Koch snowflake definitions. This approach helped the project to achieve its goal, and the Floating Base could extend itself and evolves from a district to a city as if it was a living marine plant.

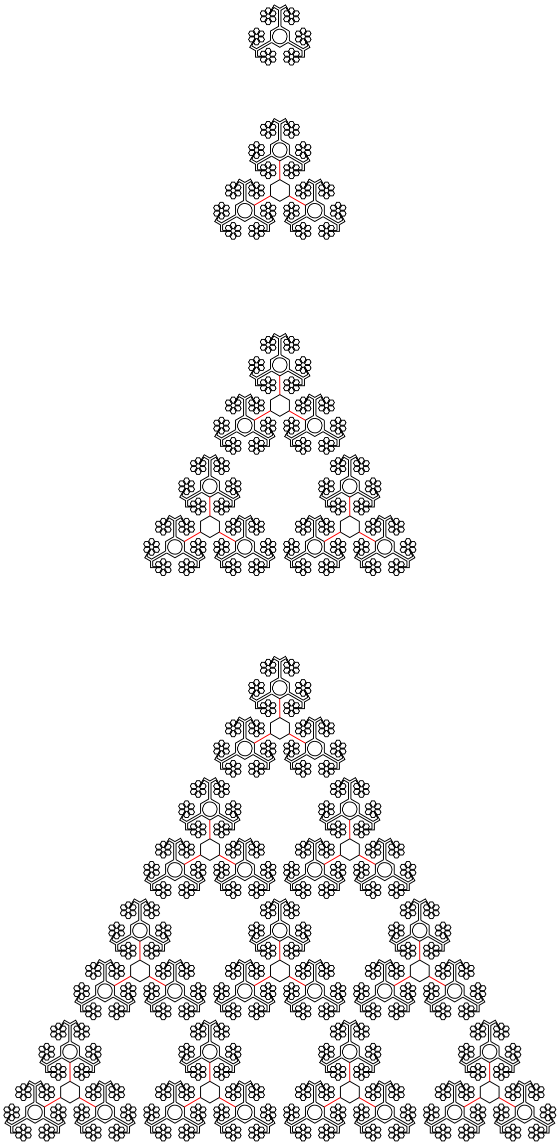


Figure 11.14: Design process of floating-Base(Autocad)

By reducing the complexity of the design and dedicating the Base-Platform more free space, the design achieved a suitable city-like shape, providing the city with enough free space, which provides enough room for parks and green areas in the center of the platform. Every eight houses have access to a central park in front of their dwellings, which provides a cluster.

Every three Cluster have access to a shopping center with restaurants restaurants if the clusters start to increase, based on the design's fractal methodology, it automatically provides more central public spaces without excessive effort.

Figure 11.15: Siteplan (Revit-Illustrator) SC:1/2000

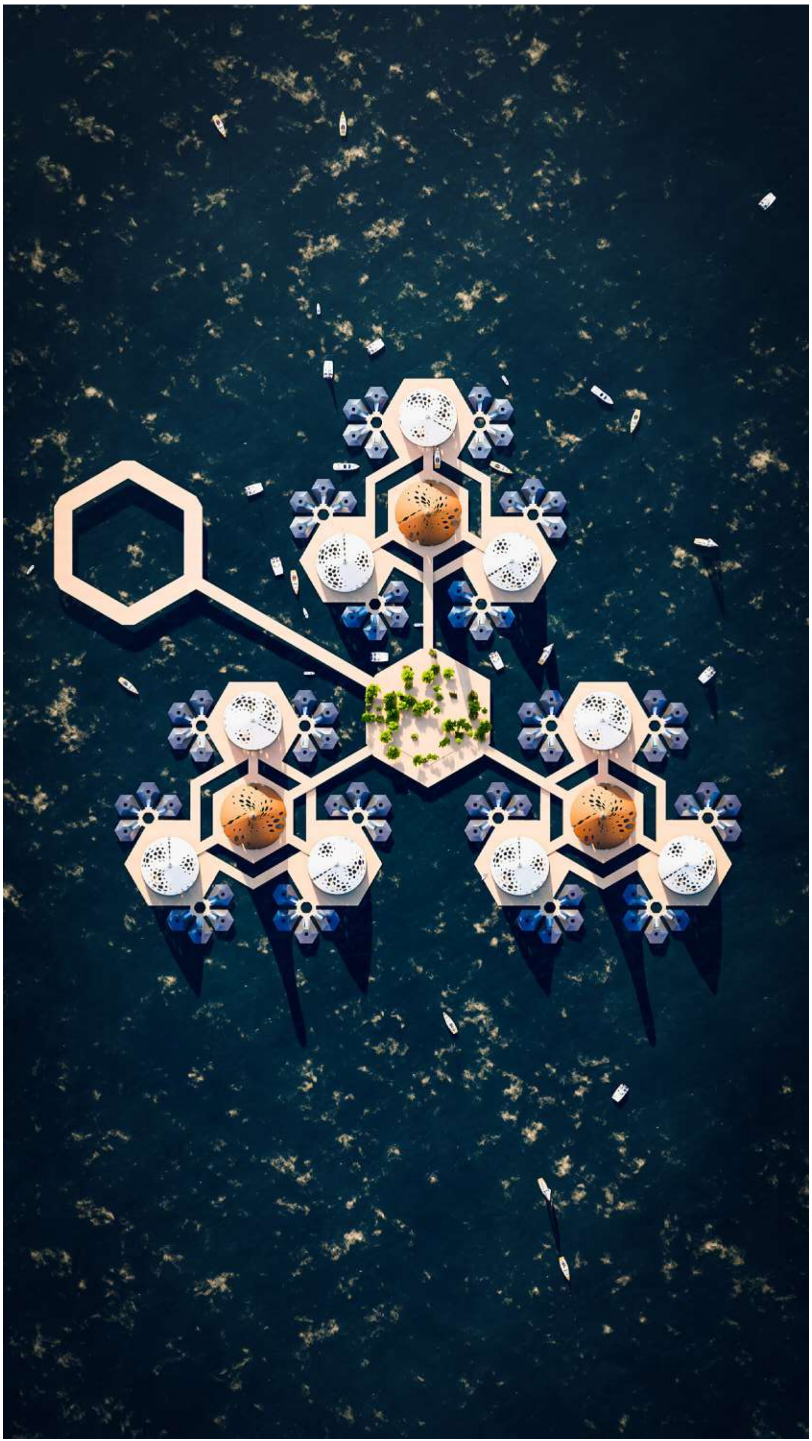


Figure 11.16: aerial view(Rhino-Lumion)

Figure 11.17: (Rhino-Lumion)

Figure 11.18: (Rhino-Lumion)

Figure 11.19: (Rhino-Lumion)

Figure 11.20: (Rhino-Lumion)

Figure 11.21: (Rhino-Lumion)

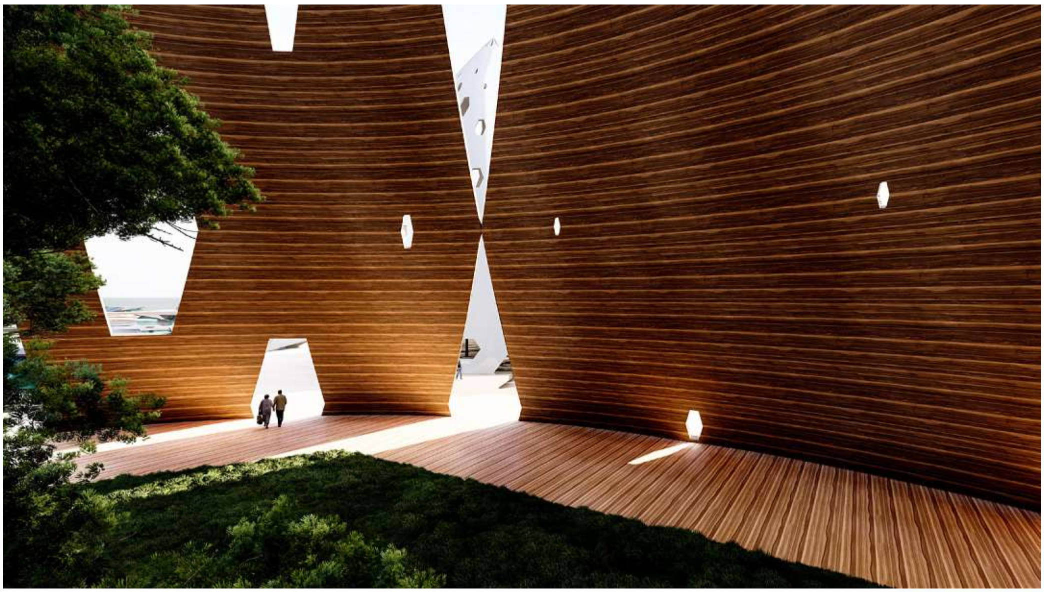


Figure 11.22: (Rhino-Lumion)

Conclusion:

Global warming and rising water levels are inevitable, and finding a practical solution to this situation can profoundly depend on our understanding of our planet. Taking control of water and floating on it, which the project of the floating house was studying, scratches the surface of one of the many problems global warming will cause us and that we have to encounter. Learning from other creatures on the planet, how they evolved, and their solutions to problems could help us find better explanations for our concerns. It would be a safe approach because natural evolution takes thousands to millions of years, and most of its mistakes are already extinct. By learning from nature and adopting its solutions in our projects, not only will we save the time those creatures used to evolve, but we also chose the safest solution. Could we translate this conversation between nature and evolution, use it in our projects, and find new solutions to our problems? The response to this question may be the difference between survival and extinction.

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