TECHNISCHE UNIVERSITÄT WIEN
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MASTER-/DIPLOMARBEIT

Nonagonale rotierende Tripple Helix
Nonagonal Rotating Tripple Helix

innovatives Hochhaus Design
Innovative Skyscraper Design

ausgeführt zum Zwecke der Erlangung
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Datum

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Abstract

Diese Arbeit zielt darauf ab, Hochhäuser als praktikablen und nachhaltigen Weg für zukünftige hochverdichtete Bebauung weiter zu entwickeln. Die architektonische Typologie ermöglicht eine hoch qualitative Bebauung, die nicht nur als Wohnraum für viele Menschen genutzt werden kann, sondern auch gleichzeitig für andere Nutzungen adaptierbar ist. Konventionell beispielsweise als Büroflächen, allerdings ausgeführt in einer flexibleren Weise und mit ungewöhnlichen Funktionen wie Schwimm- und Sportmöglichkeiten,bis hin zu innovativen, technologisch unterstützten Nutzungen wie vertikale Landwirtschaft, Schaffen von Grün- und Erholungs-räumen entlang der vertikalen Achse. Angestrebt ist ein modulares System, das nicht nur die erwähnten Funktionen ermöglicht, sondern sich verschiedenen Anforderungen des Raumes oder der sozialen Bedürfnisse anpasst.

Optimiert wird das Design durch die Möglichkeit, um einen Zirkulationskern herum zu rotieren.Die Rotation wird bestimmt durch die geometrischen Vorgaben der Aussengrenzen des Gebäudes in Verbindung mit einer komplexeren und weiterentwickelten Form, die den Hauptkörper des Gebäudes definiert. Mehrebenen Module, die fast identisch in ihrer Gesamtform
sind, werden durch Grundrisse und Höhenunterschiede angepasst, um grundsätzlich alle programmatischen Wünsche zu erfüllen. Das Design sollte an jedes vorgegebene Grundstück angepasst werden können. Um das zu ermöglichen, werden umfangreiche formelle und strukturelle Studien durchgeführt. Für die formalen Entwicklungen wurde Rhinoceros 7.0 kombiniert mit Grasshopper for Rhino hauptsächlich verwendet. Zum einen wurde ein bestimmter Rahmen für programmatische, volumetrische und strukturelle Ideen entwickelt. Zum anderen wurden spezifische strukturelle und mechanische Probleme im Detail ausgearbeitet. An diesem Punkt wechselte die Arbeit zum Gebrauch der Blenderversion 2.8-3.4 unter spezieller Anwendung des Plugin Phaenotyp in verschiedenen
Entwicklungsstufen. Die technischen und konstruktionsbezogenen Probleme wurden im Hinblick auf weitere Verbesserungen der Nachhaltigkeit und der Qualität so gelöst, dass innovative Strategien für erneuerbare Energiegewinnung eine Symbiose mit der dynamischen Natur des sich drehenden Hochhauses bilden. Dabei wurde das der Rotation innewohnende inhärente Potential für Energiegewinnung und -speicherung genutzt. Hier galt es Umweltbedingungen, wie Wetterwechsel und den Verlauf der Sonneneinstrahlung in den verschiedenen Jahreszeiten zu berücksichtigen.

This thesis aims to support the claim, that skyscrapers pose a viable and sustainable way for future highly condensed settlements. The goal is to develop an architectural typology providing a high quality built environment that can not only function as a residential quarter for lots of people but simultaneously can adapt and provide any given spacial program. Be it something as commonly found in conventional skyscrapers as office space though executed in a more flexible manner over some more unusual additional programming like swimming facilities or sports clubs all the way to cutting edge technologically supported uses like vertical farming and development of parks and recreational areas in general oriented along a vertical axis. A modular system was envisioned, that could not only facilitate all the above mentioned user experiences but also could be composed on a site to site bases in order to adapt to any possible sitespecific spacial and/or social demand. Furthermore the design is improved by the ability to rotate along the circulation core.
The rotation will be dictated by the geometrical arrangement of the buildings outer boarder in conjunction with a more complex and refined shape to define the buildings main body. Multilevel modules that are almost identical in their overall shape are adapted through floorplan and elevational variations in order to fit basically any programmatic desire.
In order to achieve this level of adaptability there will be no defined site for this project. Rather should the design be elaborated in a way that can be easily configured to any given site with few adaptations. In order to develop this structure extensive formal and structural studies were conducted. For formal developments Rhinoceros 7.0 in combination with Grasshopper for Rhino were mainly used. Once a certain framework of programatic volumetric and structural ideas was developed the specific structural and mechanical problems were examined in detail. At this point the work shifted to the use of Blender versions 2.8-3.4 under specific application of the plugin Phaenotyp in various stages of its development.Once the technical and construction related problems had been sufficiently elaborated upon the further improvement of the buildings sustainability and overall quality was achieved by application of innovative renewable energy strategies that form a symbiosis with the dynamic nature of the rotating skyscraper by drastically increasing the inherent potential for energy generation and conservation by rotating informed by environmental conditions like weather changes or simply the change of the suns path over the changing seasons.

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1 Motivation

This work has been initialy inspired by the "City-Scraper" architectural competition of 2022, which was preceeded by the "Sustainable Skyscraper Challenge" in 2019-2020. These competitions provided a welcome starting point for further studies regarding highrise design and technology. Upon exploration a great magnitude of "skyscraper design challenges" was found on various platforms hosting architectural competitions. Combined with the desire to make the most of the freedom given in an academic context the idea was formed to not only develope a cutting edge skyscraper on a technological level but also points out a different approach to the way we think about vertical consolidation of usable space.

The need for a sustainable and efficient strategy to deal with the rising urbanization and therefore rising demand for a highly densified built environment is apparent when consulting publications like the "World Urbanization Prospects Report" of 2018 by the United Nations.[1] But the mainly prevailing typology for highrise architecture remains that of a giant vertical slab cladded in a nondescript glass-facade. Mixed use designs tend to follow very similar patterns of vertical stacking of different but similar use cases i.e. hotels interwoven with dwelling units and the occasional skylobby or observationdeck in order to increase potential revenue for developers. The debate around innovative skyscrapers is mainly focused on the overall height that can be achieved, rather than the idea to rethink the composition of usecases and inhabitants that can populate a highrise with the idea to create value for an entire community living in and around the building as opposed to the maximum financial value for the developers and landowners.

Over the last years if not decades the value of economical ecological and social sustainablity have gained successively more recognition in the public discourse and scientific community. A lot of very interesting ideas have come to life on how to deal with climate and energy crises as they become more and more serious. This thesis will attempt to create synergies from various innovative technological advances and implement a wide array of strategies to develop a skyscraper-system, that could either be set up to compose a classical userprofile as described above or just as well be set up to create a uniquely bespoke typology suited to the need of the city and neighborhood it would be located in. In order to develope this adabtable system the building site will not be chosen in this thesis rather the whole focus will be placed on the development of a flexible wholistic system that can sustain itself with minimal requirements from the surroundings.

The aim of this exploration is to contribute in an exciting and inspiring way to the arcitectural discourse regarding future highrise developments and approach the design challenge inherent with that on a creative and alternative way. To reach a result that will hardly resemble any built iconic skyscraper and function in a way that has not been tested sofar.

Ultimately the motivation for this project is to utilize the opportunities given in the university context to conduct the development of a project of this scale and innovation without the limitation of financial feasability, conventional construction methods and or building site restrictions regarding zoning or political considerations. With this virtually unlimited freedom to design, think and execute ideas the best basis for an extraordinary design is set.

2 Situation Analysis

2 Situation Analysis
2.1 Competition Brief
2.2 Inspirational Projects and Innovative Skyscrapers
2.3 Renewable Energy Potentials
2.3.1 Solar
2.3.2. Wind

Skyscrapers and Mega Cities

To define an initial starting point in the situation analysis I will shortly introduce Hong Kong and New York as iconic examples for skyscraper development and continued relevance to this day. Further I will introduce the competition brief serving as an source and origin point of this exploration. Upon a first research phase some inspirational and informative projects will be named and a brief insight into renewable energies will be provided.

Hong Kong -
according to the Coucil on Tall Buildings and Urban Habitat (CTBUH) is the city with most skyscrapers of more than 150m in height namely 553.[2]
Hong Kong officially is a special administrative region of China (SAR) it is situated on the eastern Pearl River Delta in south China and has a population of 7.5 million on a territory of only 1.104 km².[3]
High rise development startet up during the 1960s and 70s due to rapid economic growth and urbanization in the area.
It's current peak has been reached with the International Commerce Center which was constructed from 2002 until 2010. With a height of 484m it is among the 15 highest skyscrapers in the world.
Since the opening in 2011 according to the CTBUH intensive measures to increase the buildings sustainablity have been implemented.[4]
This development shows a clear cut from uncontrolled settlements like "Kowloon City" and poses a great example for the benefits a society can experience through sustainable design.
Following this spirit this thesis will try to achieve a new form of sustainable settlement that is siutable to any city and any social group and will through its superior architectural quality provide a possibility for improved living conditions all around.


1: Kwooloon City


2: International Commerce Center HK

New York -
New York City is one of the most famous and arguably one of the first cities featuring major skyscraper-development. Especially in Manhattan the historically by swamps dominated island, skyscraper were build out of necessity where the soil was solid enough to support the massive loads as required for a building of this size and therefore weight. To this day the zones dominated by favorable rocky soil conditions can be clearly distinguished just by comparison of building heights in the skyline. From the tip of the island at battery park to the top in Harlem the clusters of tall buildings clearly indicate the soils conditions.

Lower Manhattan, the center of New York City which originated in the 20s and 30s of the last century over time turned into a dominating hotspot for world finance. Iconic buildings like the Empire State, Chrysler (Building), Seagram Building and the World Trade Center Twin Towers indicated wealth and power as well as the real need to put more people to work in the very limited developable space given on the island.

9/11 was a shock for the world as well as for the city and its architects.
But it is not only the threat of terrorism which created the need for architects to find new perspectives for building in Manhattan. Hurricane Sandy in 2013 exposed the vulnerability of the long time established High Rises to natural disasters and general problems related to climate change. Flooding and power outages let the city life grind to a stop for days to weeks at a time pointing out a dire need for a more resilient and self-reliant way of planing not only the way we build skyscrapers but the way we develop cities.

More recently the COVID Pandemic again forced people in large cities to give up their daily routine and yet again a multitude of problems in the current planing and building strategies employed became obvious. The long lasting practice of developing smaller and smaller apartments and reduce the personal living space as far as possible in order to enable people to still afford living accommodations in desireable cities despite the prices to rent or even buy an apartment skyrocketing over the past decade. This led to seriousproblems in wide parts of the population once the freedom to use public parks and spaces had to be limited in order to protect public health.

The design proposed in this elaboration will therefore aim to facilitate a generous amount of common and private outdoor spaces and skylobbies providing residents and “part-time-users” of the building with unconstrained acces to inviting parkscapes, waterpark-like ammenities and an innovative and exciting built environment to facilitate all the daily needs while providing ample personal space for everybody around.

3: WTC New York

WTC 1 1973-2001

417 m (413 occupied)
110 floors (8 technical)
~4.000m²/ floor
-418.000 m² (office space)
99 elevators - 23 Shuttle Express (8m/s)

4: Skyline New York

2. 1 Competition Brief

Img 1: A usual impression of a skyscraper - Concept

Premise

The promise of jobs and prosperity, among other factors, pulls people to cities. According to national geographic magazine, half of the global population already lives in urban areas, and by 2050 it is expected to swell to two-thirds. The side effect of this are the most pressing problems facing the world today also come together: Disconnect between the buildings, the city and Environmental Degradation.

As the cities continue to grow, the way we construct and manage buildings has never been more crucial to global economic and social development. Overpopulation in cities is a pressing issue, **silently aggravating the forces behind the current environmental problems**.

The vital task in a city is to pack a lot of people in one place without depleting the quality of life.

The soul of the city is in its people, culture, and heritage, architecture adds the character to it. But as we progress in time today, all we see is tall glass cutting edge buildings disconnected with the people and the city around. We must figure out how to make our cities more livable and sustainable without triggering the seemingly inevitable march of duplicity.

Img 2: Skyscrapers also have a city beneath it - A view of Empire states at night.

A Skyscraper

Skyscrapers as the name suggests, refers to the vertical desire to reach to the skies and live among the clouds. Increasing urbanisation in the recent decades has meant an upturn in construction of high rise building and towers all over the world making them a benchmark for the future buildings. Expanding cities horizontally to accommodate overpopulation would destroy more natural resources, therefore, the idea of the vertical cities is favoured. Present changes in occupation distribution and its interdependence on urban population growth due to migration, skyscrapers have shown functional benefits as well as an architectural style.

Urbanisation and white collar revolution has led to rampant sprawl in urban areas but, we can't run away from the harsh reality of limited land available for construction. Besides making the city affordable and architecturally interesting, high rise buildings are **greener** than sprawl and can foster **social capital** and **creativity**.

So, ***if density is unavoidable then how can we as a community turn density as a solution?***

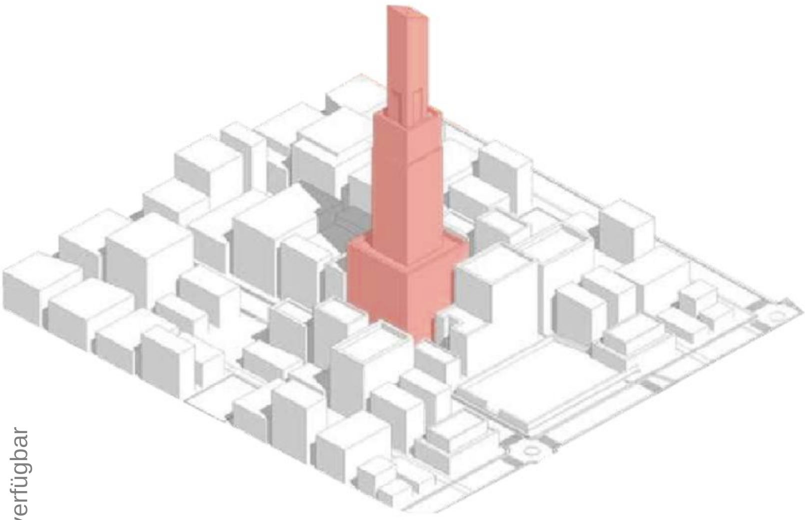
Img 5: Disconnect between building and its surroundings

Issue

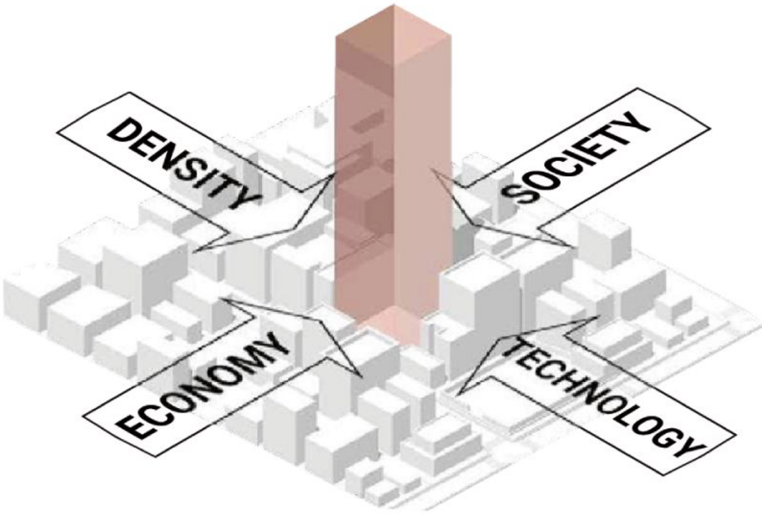
Selfish city

A skyscraper acts as a **distinctive landmark**, stamping an imprint on urban landscapes where no common man can afford to live. It's not the cars but the buildings that's the number one cause of greenhouse gases. According to time magazine, buildings account for 40% (IPCC)of energy consumption in the US Skyscraper shapes the skyline of the city but neglects the lack of interaction with the city streets and its people.

Presently, skyscrapers are designed like an **island**: **anchored at one spot**, whereas they should be designed as **stems to a city** that are made to grow the economy, environmental conditions, social and cultural well being. Skyscrapers stand high and mighty symbolising power and strength of a city and it's high time that they start contributing towards the future development of the city around.



Img 3: Physical model of skyscraper



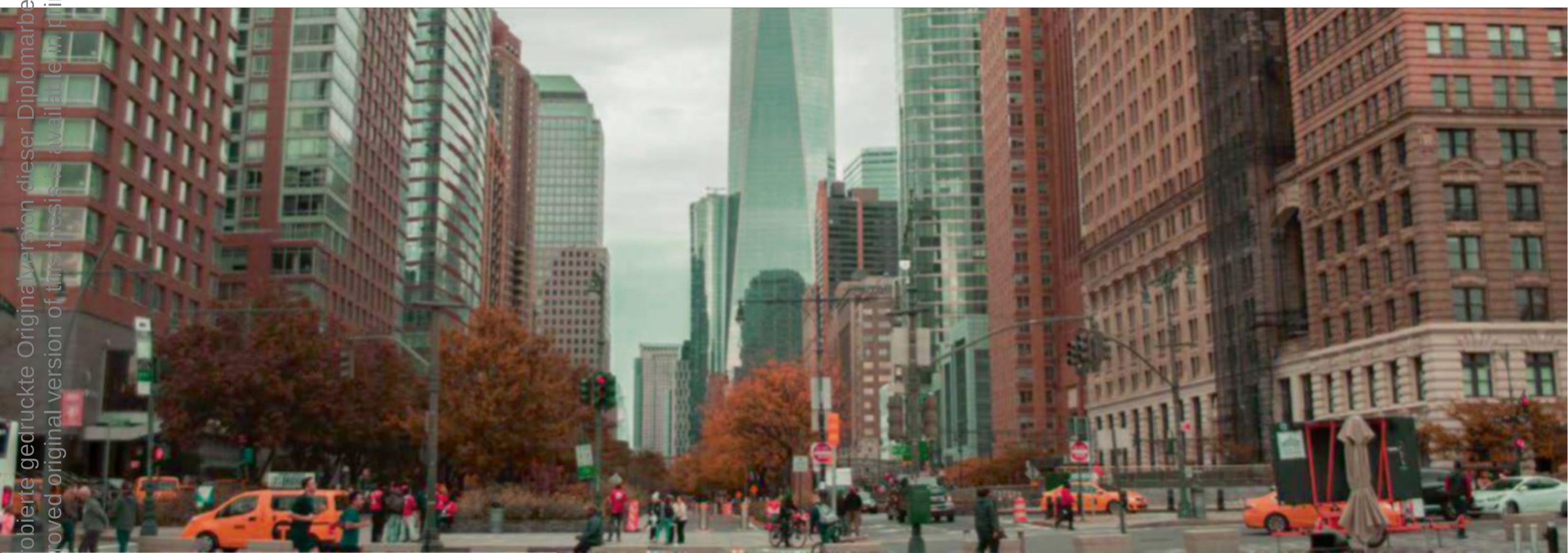
Img 4: What intersects while building a skyscraper.

Physical View

A skyscraper acts as a distinctive landmark, stamping an imprint on urban landscapes where no common man can afford to live.

Value View

But eventually it is a common point where Capital, People, Talent and Technology coincide. The responsibility goes way beyond the site because of the resources and time put into its construction.



Img 5: disconnect between building and its surroundings

Brief

Generous city

The **cityscraper** is a symposium that explores the relationship between a high rise building and the city around it. The challenge here is to design a dynamic and adaptive vertical community that serves the needs of the inhabitant at the same time being a flag bearer of global responsibility towards the city below and the planet around.

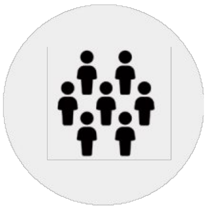
In this challenge, the design of the skyscraper springs from the rising issues of the city like, deforestation, pollution, water scarcity, waste management, etc and many growing urban issues that continuously persist which are solved with capital, engineering, and mainly offered to skyscraper design.

The aim is to engage the design without any constraints in the most creative way possible. What does a skyscraper look like to you in the future ? What are the social, cultural, environmental, historical and urban responsibilities of these mega-structures?

Objectives

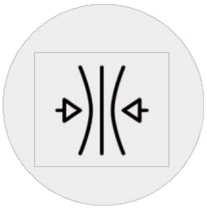
Functionality

should be functionally and structurally stable and follow local safety norms.



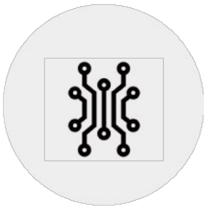
Purpose

Establishing a purpose that the building serves for the benefit of the city



Life Cycle

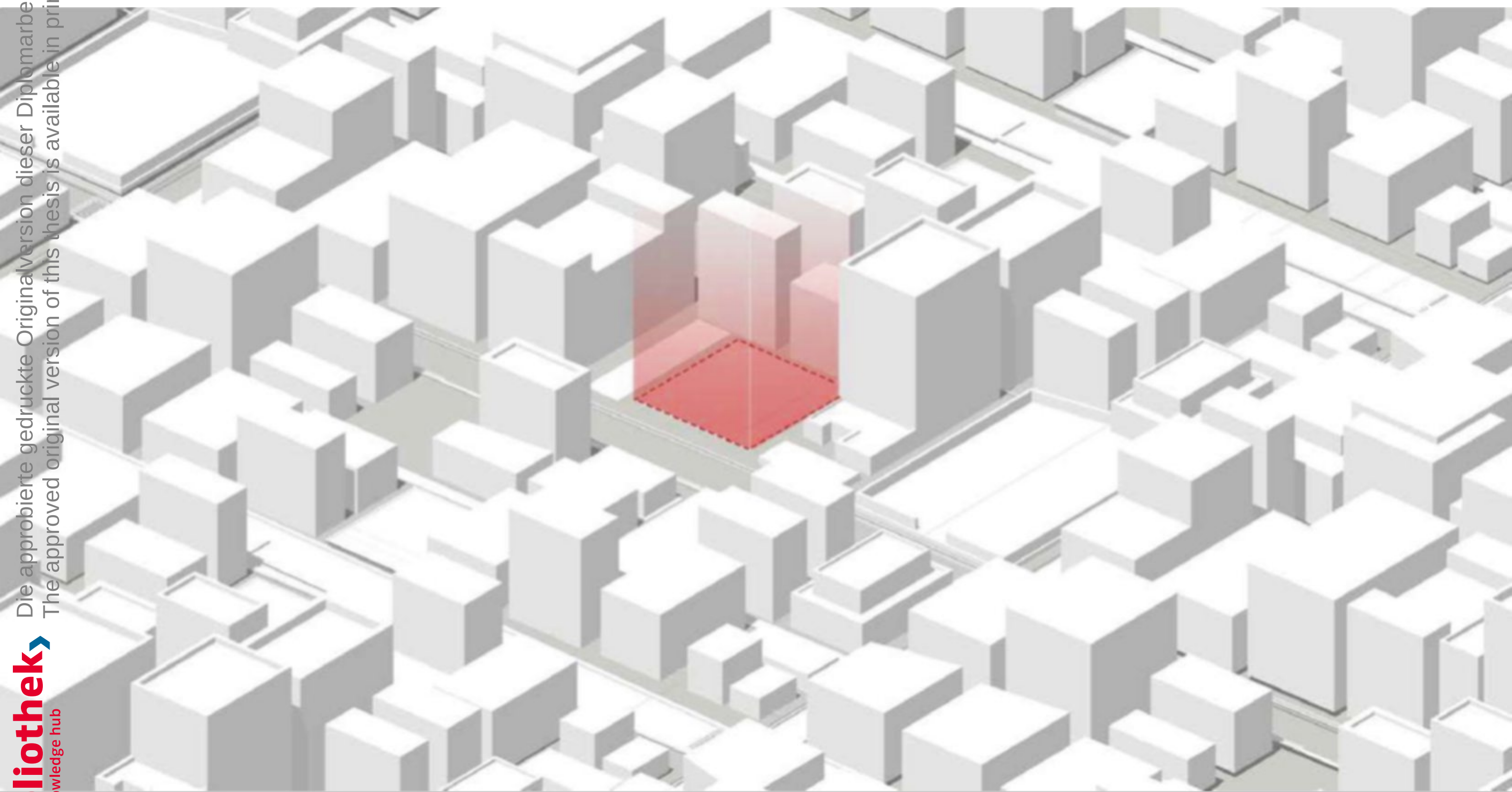
It should be able to sustain its form and function for the distant future.



Futuristic

Should take technical advancements into account (design & program).

The following objectives can be a point of beginning to conceive this design. Participants can assume their own contexts and users before initiating their design process.



Img 1: conceptual model of the site and its context

Site

The site for design can be selected in any city anywhere in the world. The place of choice can be a near future urban condition or rooted in times of today. The chosen site need not be vacant/undeveloped. If there is construction on the site you may consider it empty for this design problem.

There is no site area, height or floor plate restrictions for CityScraper.

2. 2 Inspirational Projects and Innovative Skyscrapers

Mile-High Tower

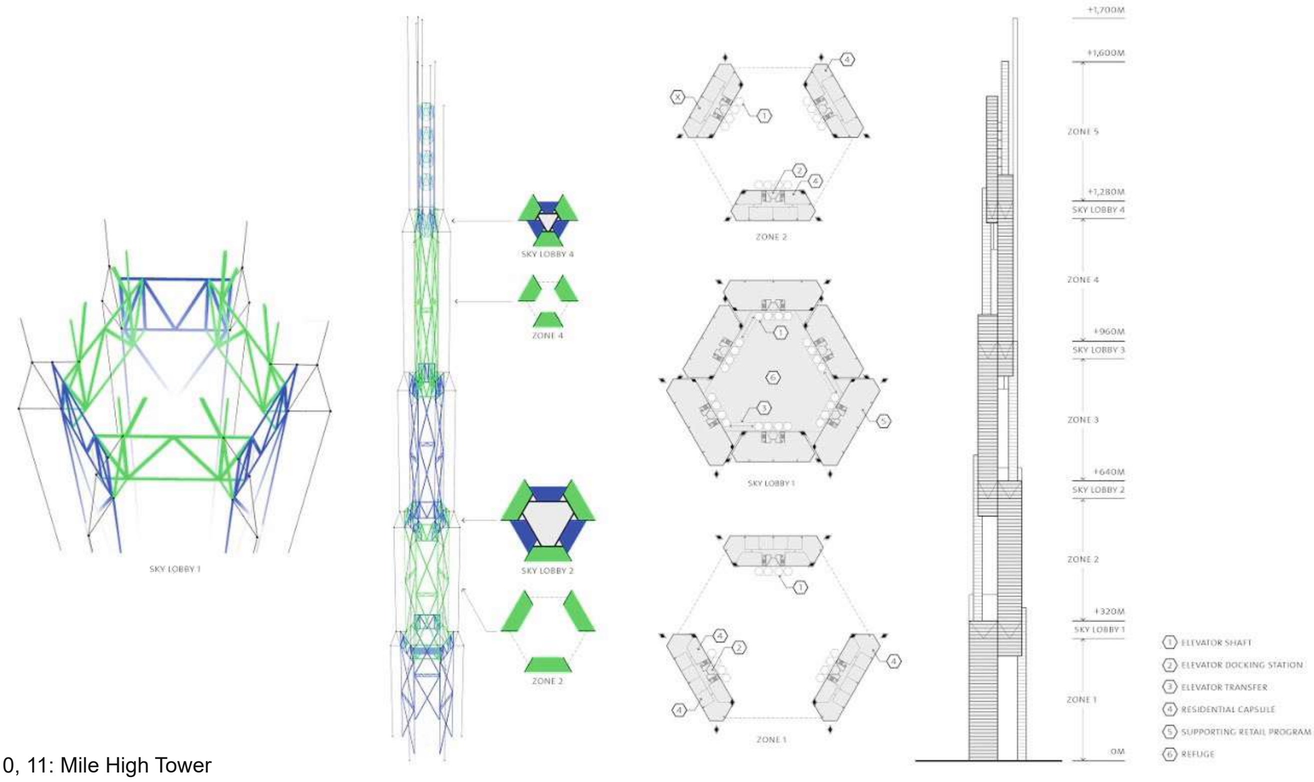
as part of the next Tokyo 2045 Masterplan by

Kohn Petersen Fox and
Leslie E. Roberson Associates

Tokyo Japan

height: 1 600 - 1 700m
floorcount: 421
floorarea: 1 375 000m^2
construction (planned):
2030 - 2045 [6]

This astonishing proposed development has a strong focus on the consequences of environmental polution and climatechange in general. The design is set on the water pointing towards the problems growing with the ever rising sealevels especially for cities like Tokyo that are situated very close to the sea and will therefore be the first ones to face these challenges head on.[5]

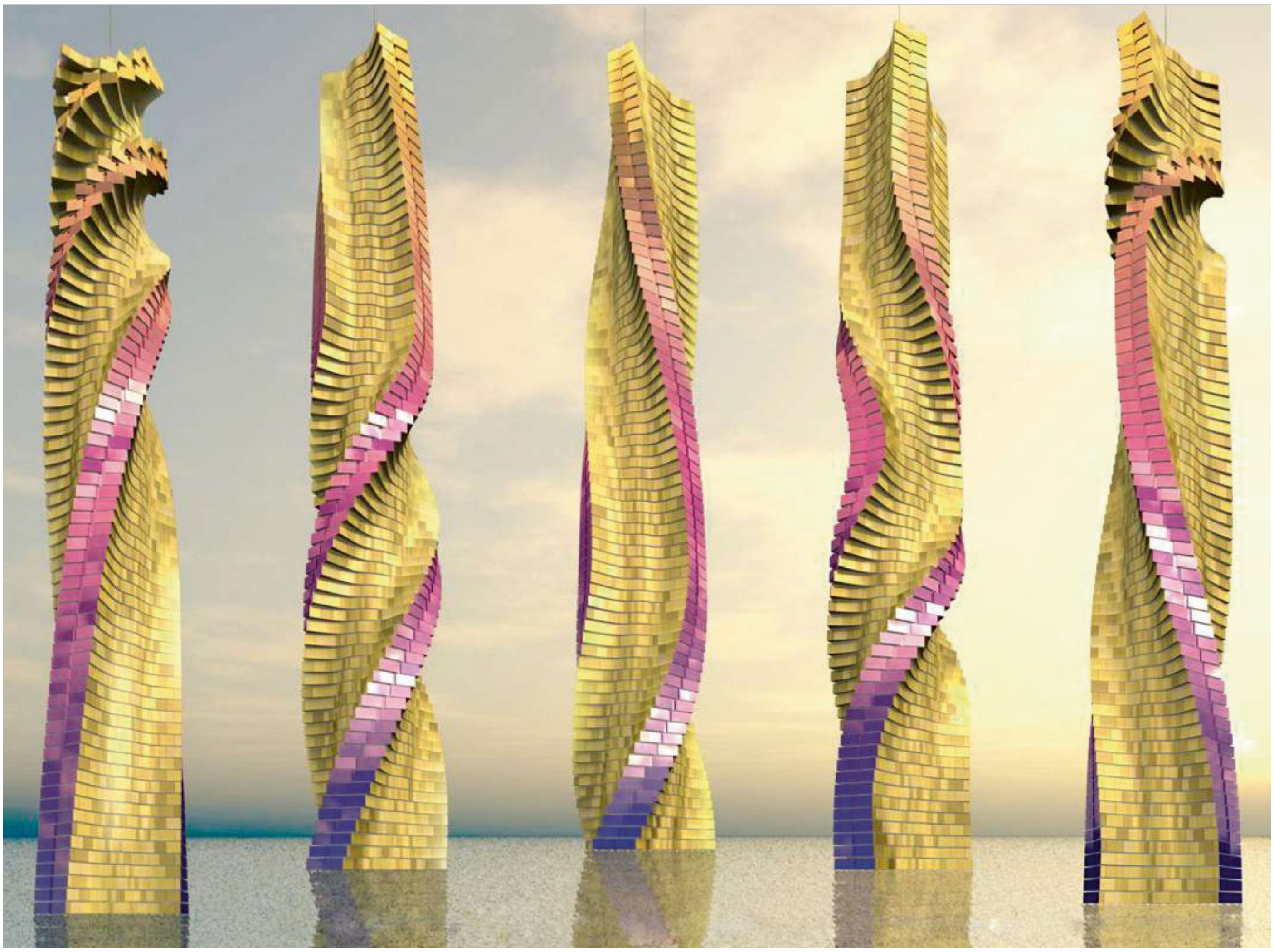


9, 10, 11: Mile High Tower

Dynamic Tower

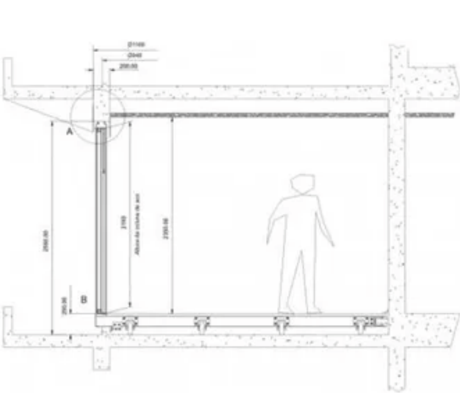
David Fisher	height:	420m
	floorcount:	80
UAE	budget:	330 mil $
	construction:	
	proposal sofar	

The proposal for the Dynamic Tower by David Fisher was canceled but would have been a rotating prefabricated tower consisting of 40 modules per floor that would have been factory build of site and transported and assembled in place. Each floor was designed to rotate at a speed of 6 meters per minute or 180 minutes for a full rotation. [7]

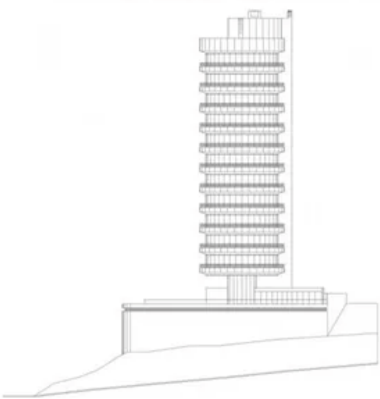


12, 13: Dynamic Tower

Examples for built “rotating buildings”



ESQUEMATIC SECTION

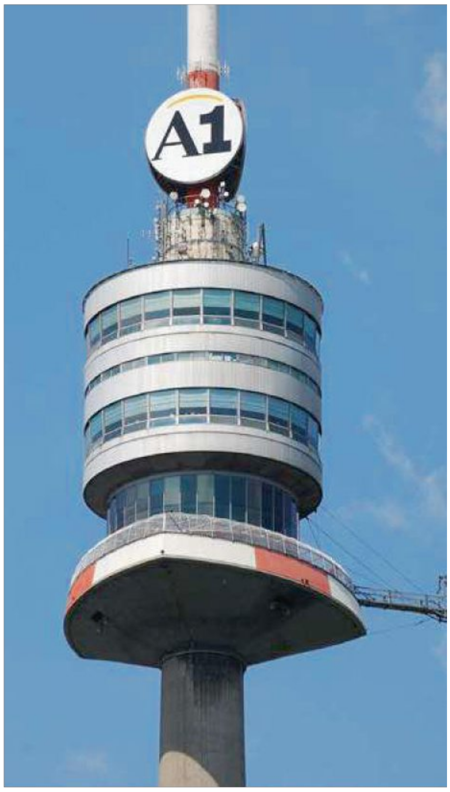


Suite Vollard (Curitiba, Brazil)

- built in : 2001
- floor count: 15
- total height (over ground): 50m
- metalframe rotating on concrete consoles
- one rotation at full load and velocity requires 0,370 kWh[8]

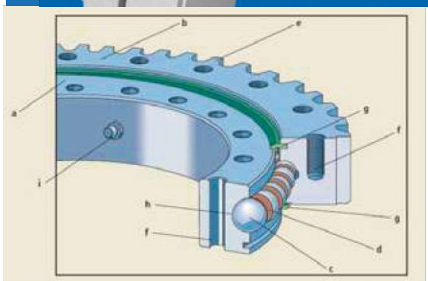
Danube tower Vienna

- rotating restaurant
- built in: 1962-64
- height of shaft: 182m
- total height (over ground): 252m
- foundation height: 8m
- first ever rotating modules with rotating connected faccade
- on every floor one engine powers a transmission with three levels
- resulting in 3 possible rotation speeds 26, 39, u 52 min per rot.
- supportet by 96 wheels that are supported on rubberbear-ings
- maintenance is conducted in January and the bearings are accessible from the technical floors situated below [9]



rotational slewing bearings analysis [10]

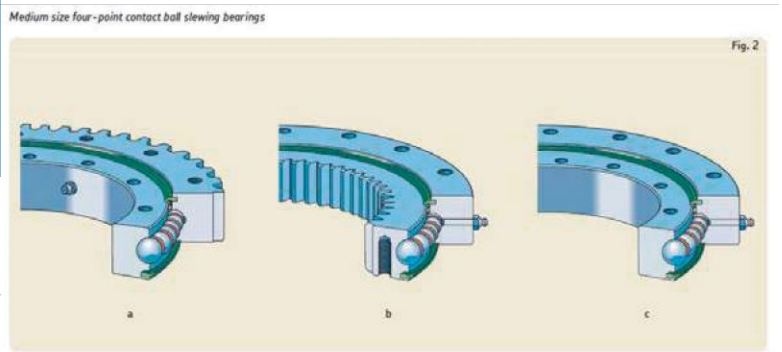
position of driving gear

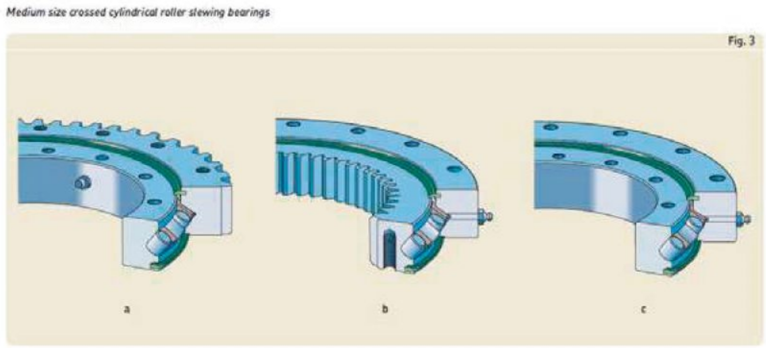


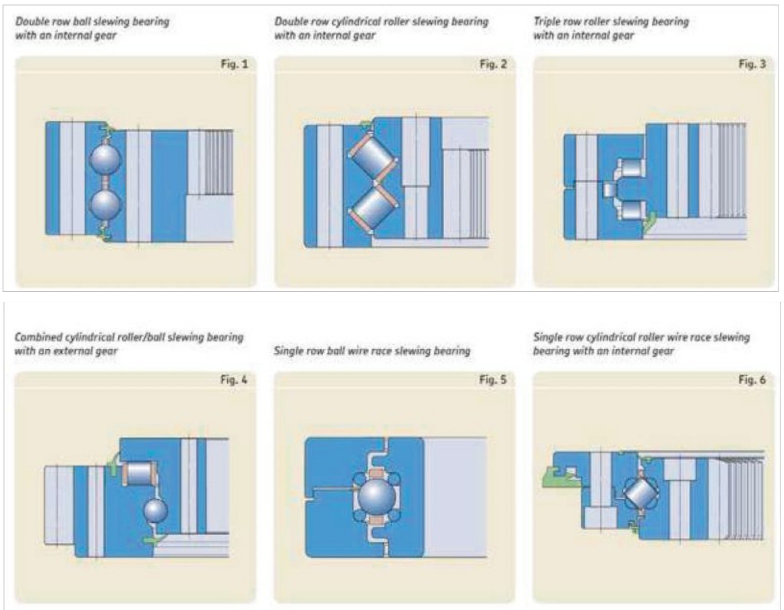
General bearing assembly

a) inner ring
b) outer ring
c) rolling elements (balls/ cylinders)
d) spacers (polyamid/ metal)
e) gear (outside/ inside)
f) attachment holes
g) seals
h) raceways

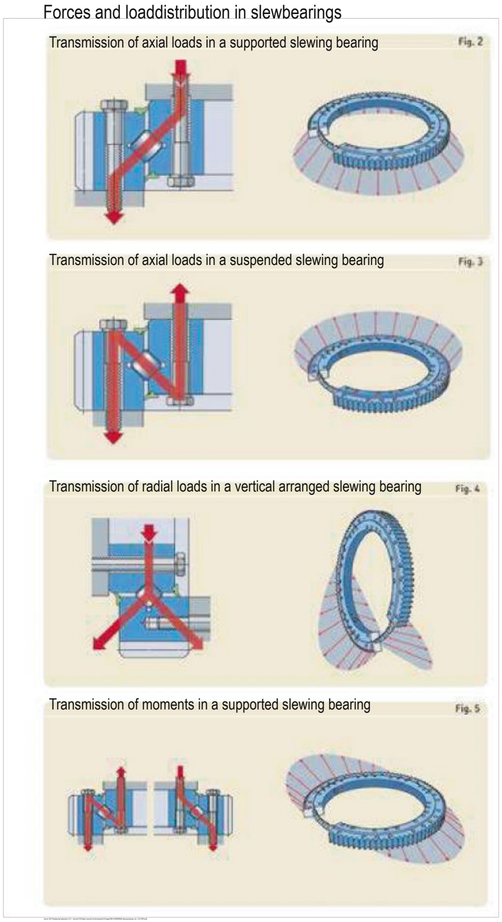
types of slewing bearings





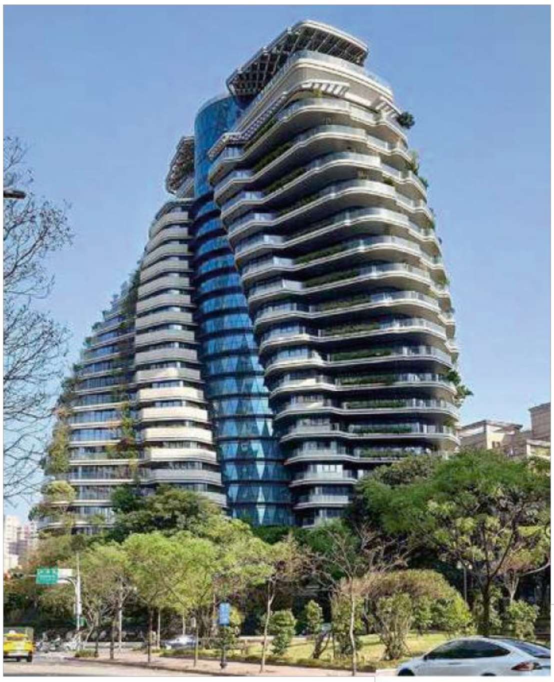


Forces and loaddistribution in slewbearings



Examples for “vertical gardening”

Agora Tower



Taipei Taiwan
90 deg. rotated tower
by Vincetn Callebaut
height: 93 meters
construction: 2013-2017
opened: 2018 [11]

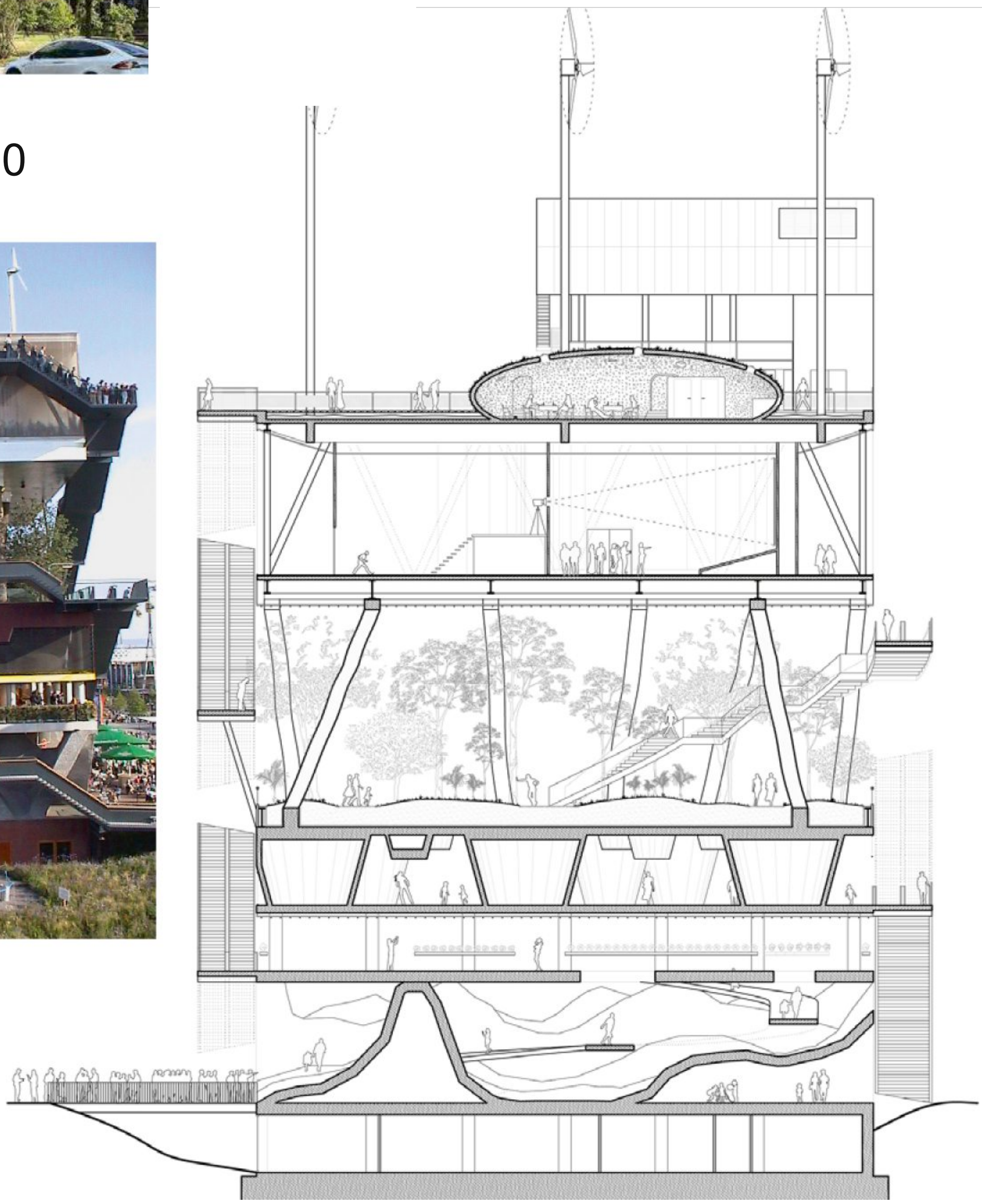
Bosco Verticale

Milano
Boeri, Barreca, La Varra
vertical forest in Milan
height: 76 & 111 meters
construction: 2009-2014
floorarea: 360,000 m^2[12]

Expo Pavillion 2000

MVRDV
Hannover, Germany

height: 36m
floorarea: 8000 m^2
budget: 10,800,000€[13]



Examples for Windenergy utilized in Skyscrapers

Bahrain WTC

first Skyscraper to integrate windturbines in the design

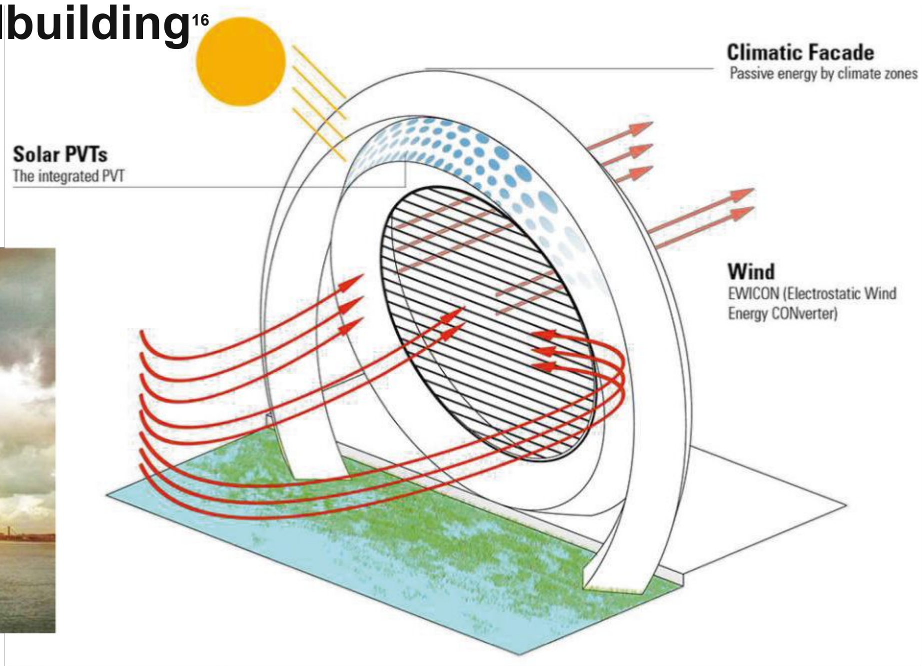
height: 240 meters
firms: Atkins; Norwin A/S
construction: 2004-2008
number of turbines: 3
turbine height (m): 60; 98; 136
turbine diameter: 29 meters
turbine capacity: 225 kW each
MWh /year: 1,100-1,300[14]

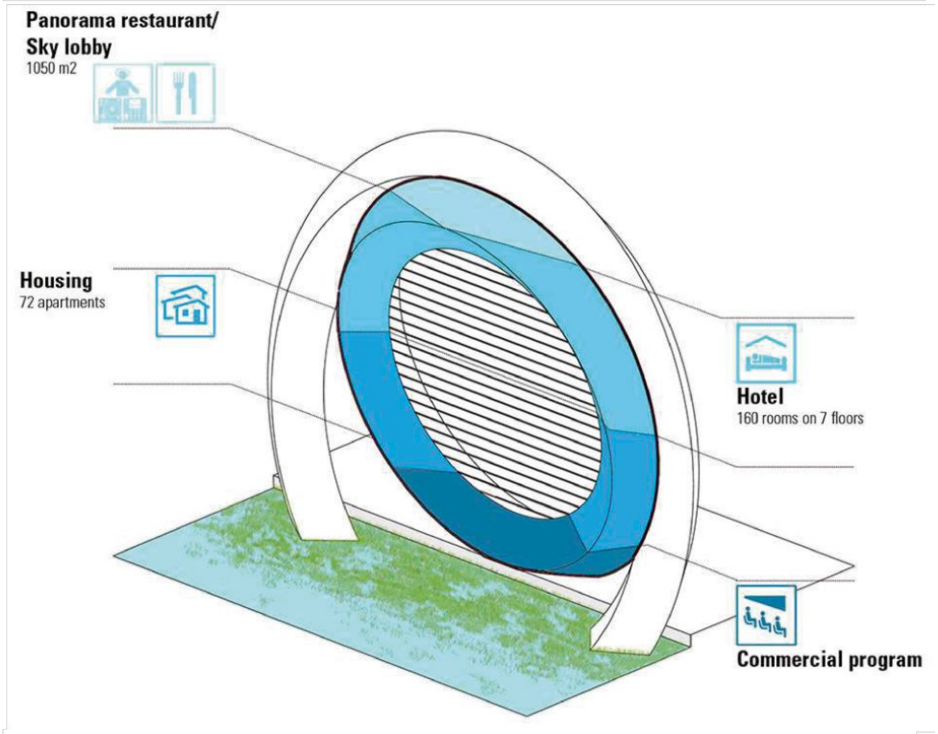
Strata SE1

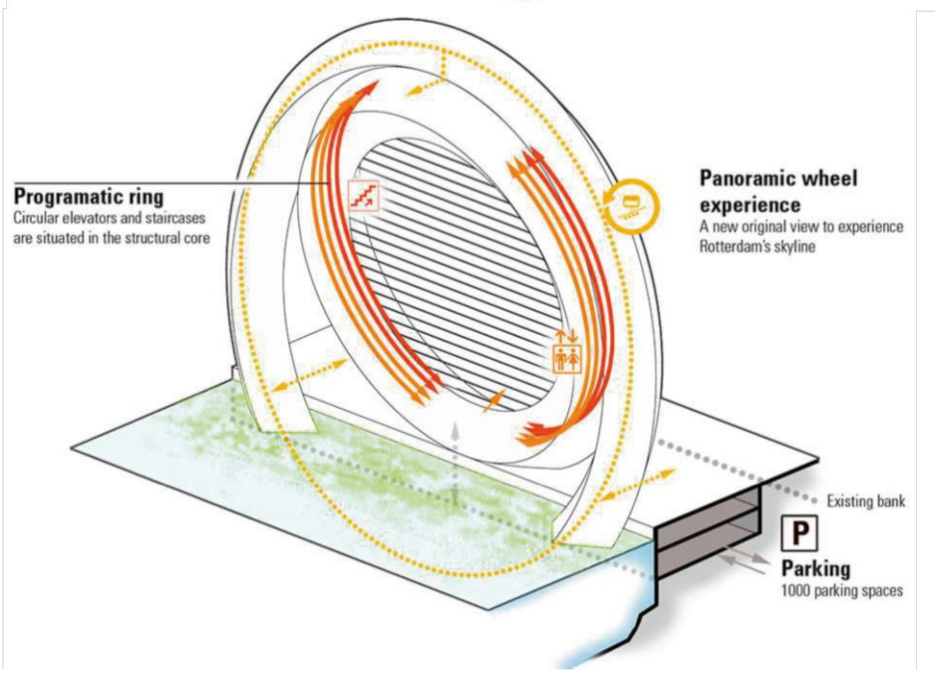
tallest residential building in London at time of completion

height: 147 meters
firms: BFLS; Brookfield; others
construction: 2007-2010
number of turbines: 3
turbine height (m): 60; 98; 136
turbine diameter: 18 meters
turbine capacity: 225 kW each
MWh /year: 50 [15]

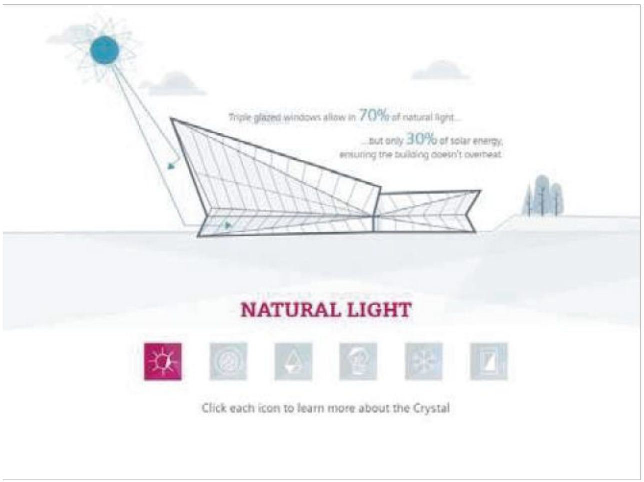
The Dutch Windwheelbuilding[16]

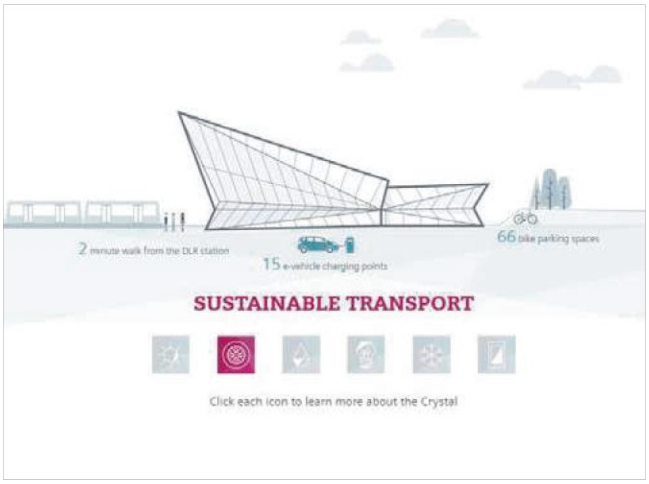


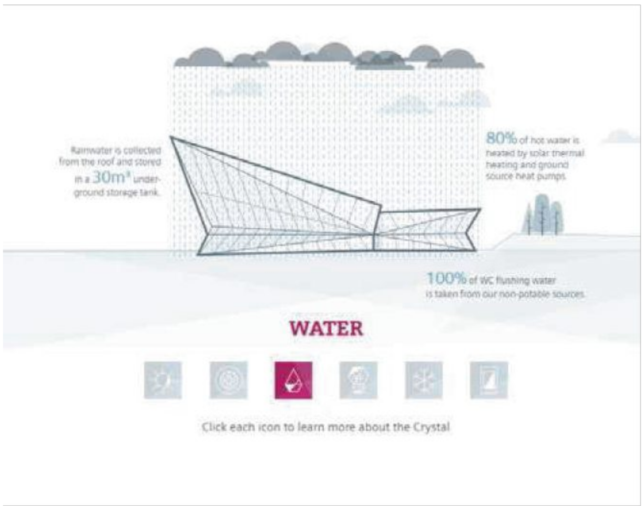


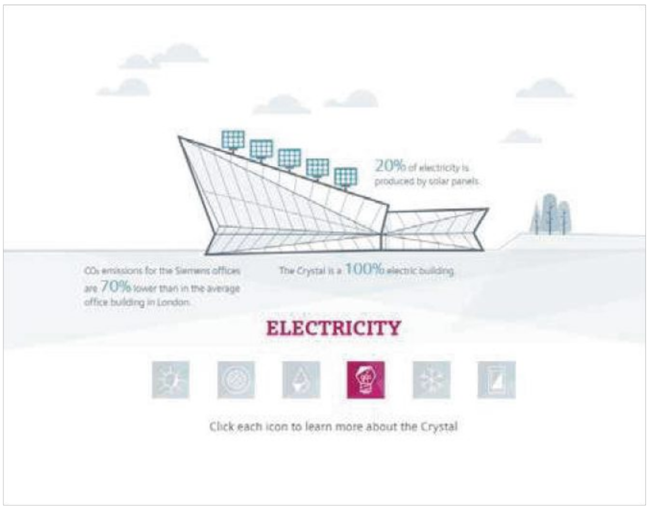


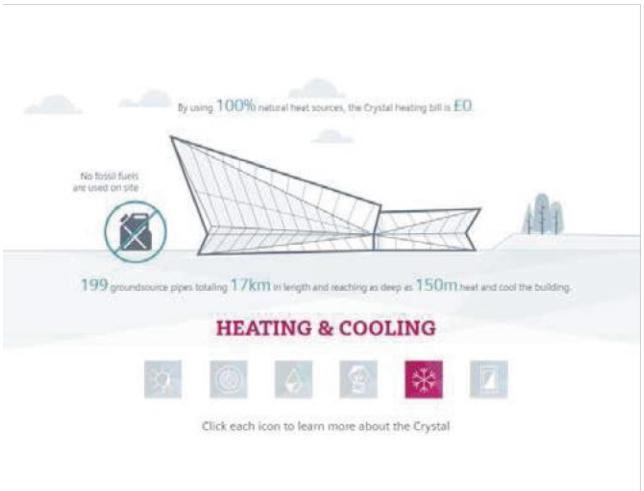
The Crystal - London Cityhall[17]

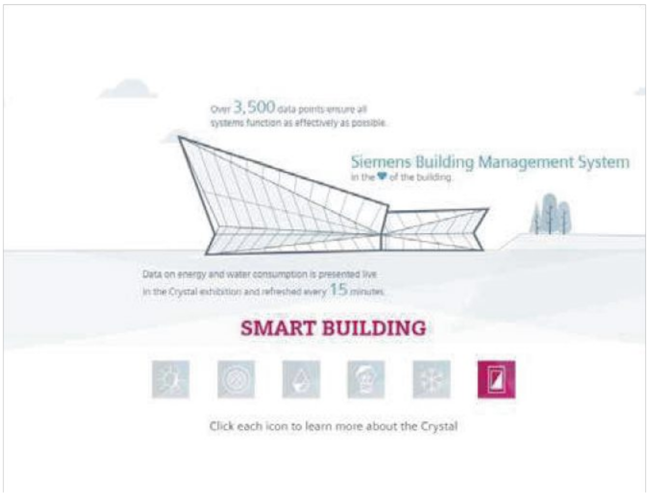












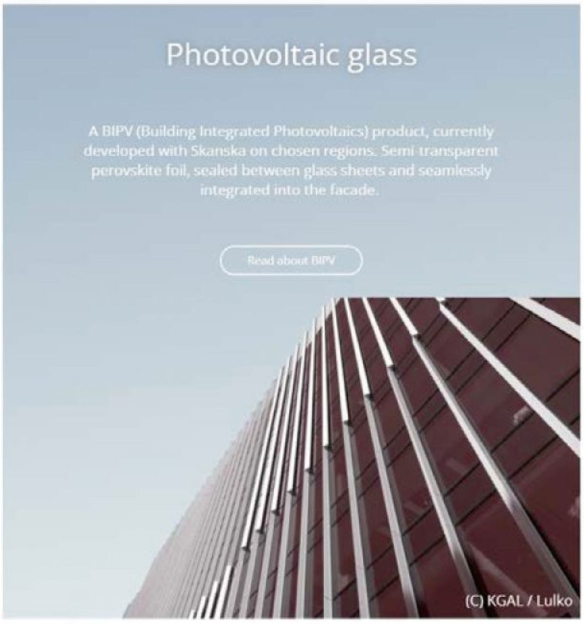
2. 3 Renewable Energy Potentials

Energy efficiency is a very important factor in building technology since the climate crisis is constantly accelerating. EU Commission and EU Governments decided already in 2021/2 that new built houses should be Zero Emission Buildings (ZEB). This regulation will take effect for public buildings in 2027 and for other buildings in 2030.[18]
These are just some interesting bullet points outlining the growing demand for development of sustainabl and environmentaly conscious architecture. In a response to this demand I will implement some leading technology advancements in the field of renewable energies in the construction of the skyscraper. Of course the entire scope of new advancments in sustainable enegry solutions could not be covered in this paper therefore only a brief overview of some selected products and technologies will be given and applied to the final design.

The impact of solar energy has grown in the last 12 years to the extent that solar energy now is the second most important energy resource: in 2022 1. 053. 115 MW of solar energy have been produced.[19] In Austria first resource for renewable energy of course is bio energy, followed by hydrogen power. Solar Power only makes 4% of the whole electricity production.[20]
But chances are good this might change in the near future. As mentioned before technical advancments are quickly progressing.
Looking at the new development through Perovskite Solar Cells we see a more capable form of photovoltaik. The first generation of Silicon bearing photovoltaic systems is now followed by this obviously more efficient combination of different layers and possibilities.[21]
Perovskite Solar Cells are delivering more electricity than average „old fashioned" solar cells.[22] The basic principle of these perovskite cells is to bundle the light through a special glas like film to explain it in the most simple terms this allows the light to be bent by a few degrees within the pv-cell and therefore eleviates the problems with efficiency variing vastly depending on the orientation of solar cells and the position of the sun - light hitting the panels at to much deviation from a 90° angle will hardly have any powerproducing impact.
A new company - "Saule technologies" was founded in 2021 with a new method to produce Photovoltaik Panels coated with Perovskite film on it which is made with an inkjet printing procedure. But still the problem exists that these Perovskite Solar Cells struggle with longer durability.[23] But in Europe as well as in the US and South Korea big enterprises are working on solutions for this problem.
Among the many advantages of this technology are for example the facts that the cells are by far the most versatile and efficient types, as explained above they are applicable in a much wider array of light situations besides they can be printed in a color of choice providing architects and designers with complete freedom in the design of sustainable structures. Besides these factors the low cost and technologically easy production of the cells allows for a high scalablity of their possible applications.[24]

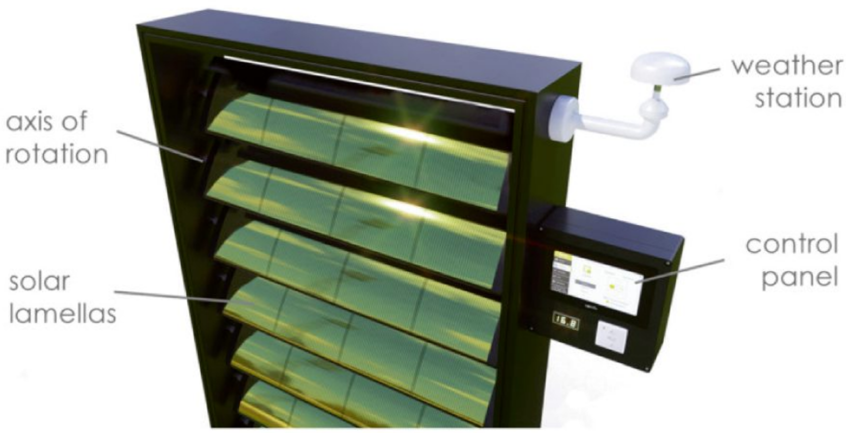
Perofskite solar panels will be used in the high-rise as electricity producing units. Depending on the construction site that might be chosen eventually the exact locations and orientations for the solar panels can be defined according to solar studies conducted accordingly.

2. 3. 1 Solar



The demonstrator

The demostrator presented during the product premiere was a proof of concept for the solution. The demostrator had all the elements of the product – operational slats with perovskite PV, regulation mechanism, control screen and a weather station collecting the data for performance optimization.



2. 3. 2 Wind

Airiva by Joe Doucet




RidgeBlade®-system

O-Wind Turbine

EWICON bladeless wind tur-

Besides the advancements in solar technologies there are also many very interesting developments to be mentioned regarding renewable energies sourced by wind. Following are some of the most interesting ones I came across in my research.

Airiva

The "Airiva Wind Turbine Wall" was invented by Joe Doucet to fill "the significant gap for sustainable energy in built environments where solar and large-scale wind turbines are often incompatible."[25] Doucet explains that wind turbines are often unsuitable or are encountered with rejection due to their outer appearance. But the wind turbine wall has more than just an appealing design: the "kinetic wall", as it is called by Doucet, consists of rotary blades arranged in a row. The spinning blades are connected to a generator that produces renewable electricity.

Next to the utilization for already existing built environments, as above quoted, Airiva is perfectly suitable for building facades and one of its advantages is furthermore that it can be installed and used beside other power generating technologies.[26]

RidgeBlade®-system

The "RidgeBlade®" wind turbine was developed by "The Power Collective" a company from Ontario, Canada. It uses the so-called Aeolian wind focus effect: "This is where the wind is forced to travel over the roof surface and forms a pinch point at the roof ridge, accelerating the airflow through the turbine."[27] It is based on the premise due to the explained effect, that the air flowing through the turbine is three times higher in speed according to the angle. In contrast to more established, like horizontal axis wind turbines, and depending on the airflow, it can produce up to nine times more energy. A big advantage of this kind of technology is that the blades regulate themselves. In case of storms where the wind speed heightens to a certain degree the distance between the blades "results in flow separation and torque loss at high wind speeds, so the system doesn't require external or other mechanical braking systems."[28] These are also factors that make it an ideal fit for the application in a highrise building given the generally higher speed velocity at large heights.

Round O-Wind Turbine

The round O-Wind turbine is an omnidirectional wind turbine that was invented by two students at the Lancaster University: Nicolas Orellana and Yaseen Noorani. The idea was to bring wind harvesting technologies from the countryside into big cities and to harvest wind in urban areas with forms of electricity production adapted to the special characteristics of highly populated and densely built environments. The traditional wind turbine was not considered as suitable because they are constructed to use wind that comes only from one direction. The accumulation of high-rise buildings in big cities affects the wind flow to an extent where it hardly ever flows constantly from one side. It is constructed as described in the following: "The round O-Wind Turbine, 25 centimetres in diameter in the current prototype, has vents sliced into the surface that allow wind to flow in from all directions, spinning the sphere on a single axis like a globe. This powers a generator that converts the energy into electricity, which can either be used directly or fed into the electricity grid."[29] By the time as can be seen in the image on the previous page a prototype of roughly 10 times the size (~2.5m in diameter) has been built and tested.

EWICON bladeless wind turbine

EWICON stands short for "Electrostatic Wind energy CONvertor" and was designed by the Faculty of Electrical Engineering, Mathematics and Computer Science's (EWI) of Delft University of Technology.[30] The "EWICON bladeless wind turbine" is characterized by the fact that it uses charged water droplets instead of moving blades or any other kind of moving parts. Moving blades have caused criticism because they tend to be high in maintenance and are high in risk of harming birds. Other advantages are that it does not produce too much shadow or noise. Instead of using mechanical energy the water droplets are charged and located in tubes that contain "several electrodes and nozzles, which continually release positively-charged water particles into the air. As the particles are blown away, the voltage of the device changes and creates an electric field, which can be transferred to the grid for everyday use."[31] The tubes are horizontally arranged in a steel frame.

3. Aims and Objectives

One of the initial contemplations regarding the beginning of the thesis and the design challenge of a sustainable skyscraper was - to utilize the given forces and potentials of a super tall structure as much and as innovatively as possible. In order to facilitate a cutting edge concept for energy preservation and generation through entirely renewable energies some of the most important examples have been analysed and applied to the design. Unfortunately it would exceed the scope of this paper to simulate and calculate the actual energy gains, needs and losses for the final design proposal. The well informed positioning and application of various modern energy solutions should still be a dominating factor in the designs qualities.
Another important goal of this thesis is to envision a new and innovative typology for highrise design and development. The aim is to analyse the current state of technologies and consider possible future developments regarding renewable and sustainable energy generation in connection with small scale powergeneration on a building integrated scale as well as power-demand-reducing measures to acchieve a building type that provides superior spacial qualities and experiences for inhabitants and visitors while also setting new standards for energy demand and low dependency on urban infrastructural supports.
With technical developments proceeding at an ever increasing speed it can be speculated that within a comprehensible timeframe the development from a low dependency structure towards a fully autonomous highrise might be possible.
Originally the reaction to the competition brief was the idea to develope a vertically condensed city scape providing inhabitants with all the necessities, comforts and recreational facilities to lead a fullfilling live without ever having to leave the highrise. This approach was quickly discarded again though after serious contemplation of problems arising in this scenario. Since the - depending on perspective maybe even distopian - concept of the “vertical city” does not seam feasable the new above mentioned goals were found. The design informed by cutting edge technologies aims to achieve a relevance in all different social climatic and political regions of the world.

The ultimate vision for the project is, to be applicable for all imaginable scenarios. Be it a rural area with lacking connection to basic infrastructure where the building could become a beacon of hope for improved living conditions by providing locals with means to electricity fresh water, housing and even the possibility for commercial spaces to initiate small businesses. Or be it in existing cities. The adaptability goes so far as to be able to provide in the same structural system on the one hand if required an entirely commercially used skyrise in areas where the demand for living quarters has been sufficiently met but as a consequence has caused a lack of commercial and or recreational spaces.
A setup for the spacial programming of my design will be possible that does not include any living units but therefore even provides the possibility to creat quality nature space on a vertical axis for communities in otherwise almost entirely soil sealed areas. On the other hand in mega cities where the need for quality residential developments seams to be never ending it provides a perfect opportunity to achieve a highly condensed urban fabric in any possible location while also drastically improving the quality of life for inhabitants and neighbors alike. In an ideal scenario the development might even be able to creat and improve local micro climats prevailing in many huge cities now a days. Providing a much needed compansation of over heating glass facades and asphalt plazas. Luscioous inviting green oasis will be pertruding through the variable and yet uniform facade of the nonagonal tripple helix development. These green islands will provide shade fresh air reliefe from particulate matter expelled from traffic.

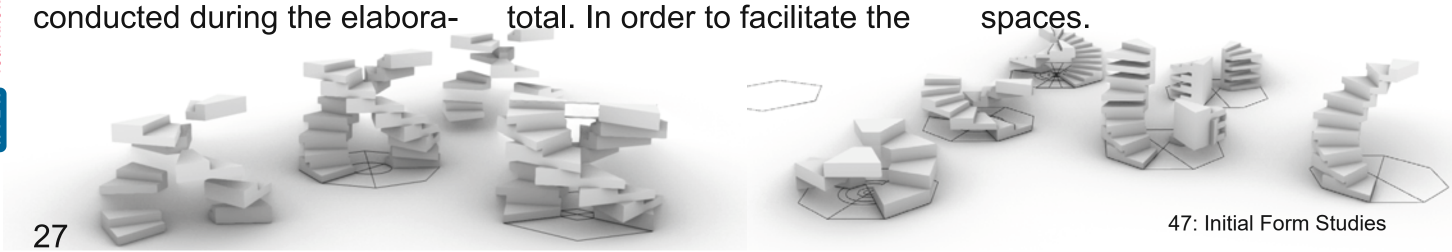
4. Concept and Methodology

4 concept development

4.1 Greater Geometry - From Propellor to Tripple Helix
4.2 Adaptability
4.3 Formline Variations after Rotational Concept Confirmation
4.4 Structural Schematics
4.5 Rotational Bearing on Console
4.6 Circulation Development
4.7 Initial Structural Explorations
4.8 Final Structural Modules

4.1 Greater Geometry - From Propellor to Tripple Helix

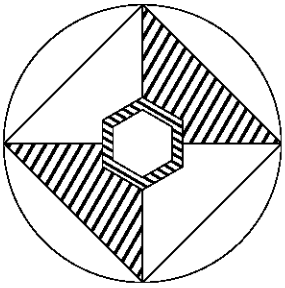
After the initial examination of the topic and possible approaches I chose to follow a design that felt the most promising regarding contemplatoins of sustainability adaptability and innovation. I chose to build up my design based on the shape of a propellor. First starting to look at double edged propellors and analysing geometrical shapes correlating to the form I soon moved on to explore the possibilities provided by a propellor equipped with three blades.
On the following page some basic studies of geometrical shapes can be seen.
The fundament thought behind this step was to define an outer boundary for the project. Since I decided rather early on that I will design a building independend from a building site it was clear that the outer shape had to be informed in a way to facilitate basically any given spacial condition and provide a fitting ensemble in spaces no matter how they are shaped. Obviously a certain minimal area has to be provided in order to even consider the construction of a skyscraper but beyond that through the basic geometrical shape the building or a cluster of buildings designed following the typology can be used to populate any given site not matter the dimensions and extends on an upwards scale.
On the following pages I will depict some of the studies conducted during the elaboration of the thesis to test which building shapes are most siutable for the design I envisioned.
From the inspirational object of the propellor the thought to create a rotating tower was not to far. The stacked and rotated propellors were analysed in the process soon the shape of a double helix arose. This was a very intruiging next step and confirmed the first explorations leading to interesting results.
To further elaborate on the concept the shape had to be guided from a rough idea to a more refined architectural concept. On the bottom right side the condensation of months of studies of shapes and variations can be found.
The basic steps that compose the DNA of the building so to speak are the definition of an outline, once this outline is decided upon a first volum is beeing extruded to create a space. Now the consideration of verticality on the smalles scale within the highrise becomes necessary. Through the rotation modules are beeing formed through stacking of single floors. This enables for a more efficient use of space and reduced complexity with regards to rotational bearings necessary to facilitat a rotating tower. Initially it was decided to create modules of 3 stories with ceiling hights of 4.5m each resulting in rotational modules of 13.5m height in total. In order to facilitate the above mentioned geneorus private outdoorspaces each floor is set back this setback has been examined in various executions and was finally defined with a area reduction of roughly 20% per floor following the the tangential axis running along the buildings outer edge. Upon creation of the setback teracces the modules will be stacked again working towards the buildings composition as a whole.
Next up the rotaional element is beeing introduced to the concept and tested regarding its feasability. After analysis of some existing and never completed designs working with moving buildings a decision was made to free up the highes of the 3 levels included in the modules in order to give the building a lighter feeling and also avoid conflic between the rotating parts. Since this meant that the useable area was reduced by a significant amount eventually the conceptual step of additional condensation was implemented after first floorplans had been developed. This further extended the wide array of adaptability options included in the design given that the same structural framework now provides rotating units with either 3 floors of 4m ceiling height or 4 floors with 3m ceiling height. As mentioned above the additional Meter of space is required to facilitate the rotational bearing and associated technical spaces.



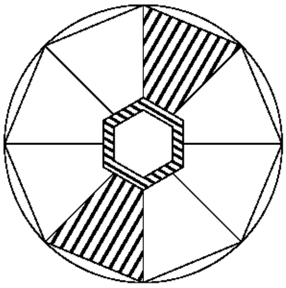
47: Initial Form Studies

Concept Diagrams:

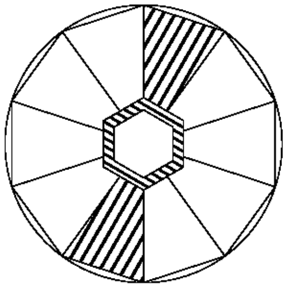
48:
double edged pro-
pellor



square

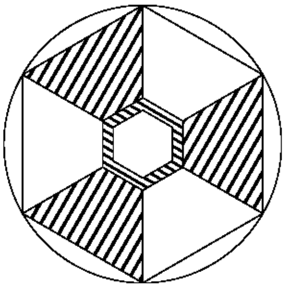


octagon

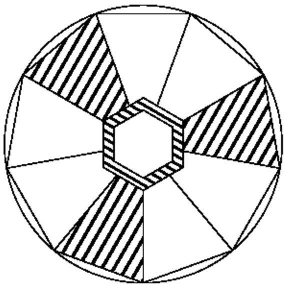


decagon

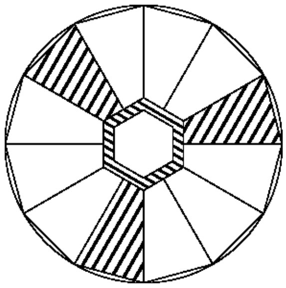
49:
tripple edged pro-
pellor



hexagon



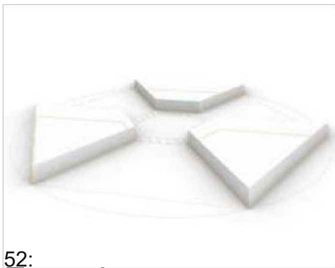
nonagon



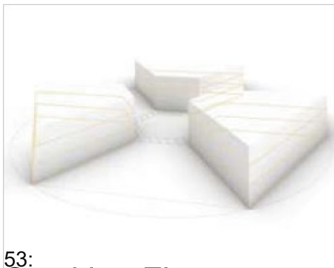
dodecagon

50: 6 Geometric Options

51:
Outlines



52:
Extrusion

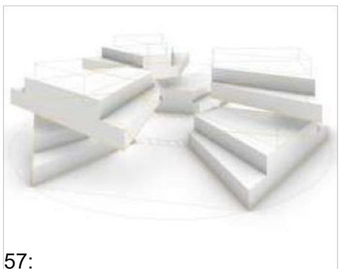


53:
Stacking Floors

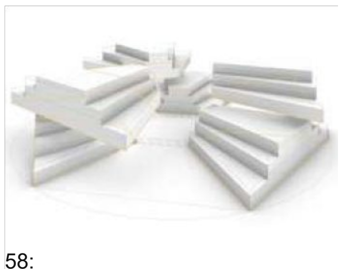
54:
Setting Back

55:
Stacking Modules

56:
Rotating



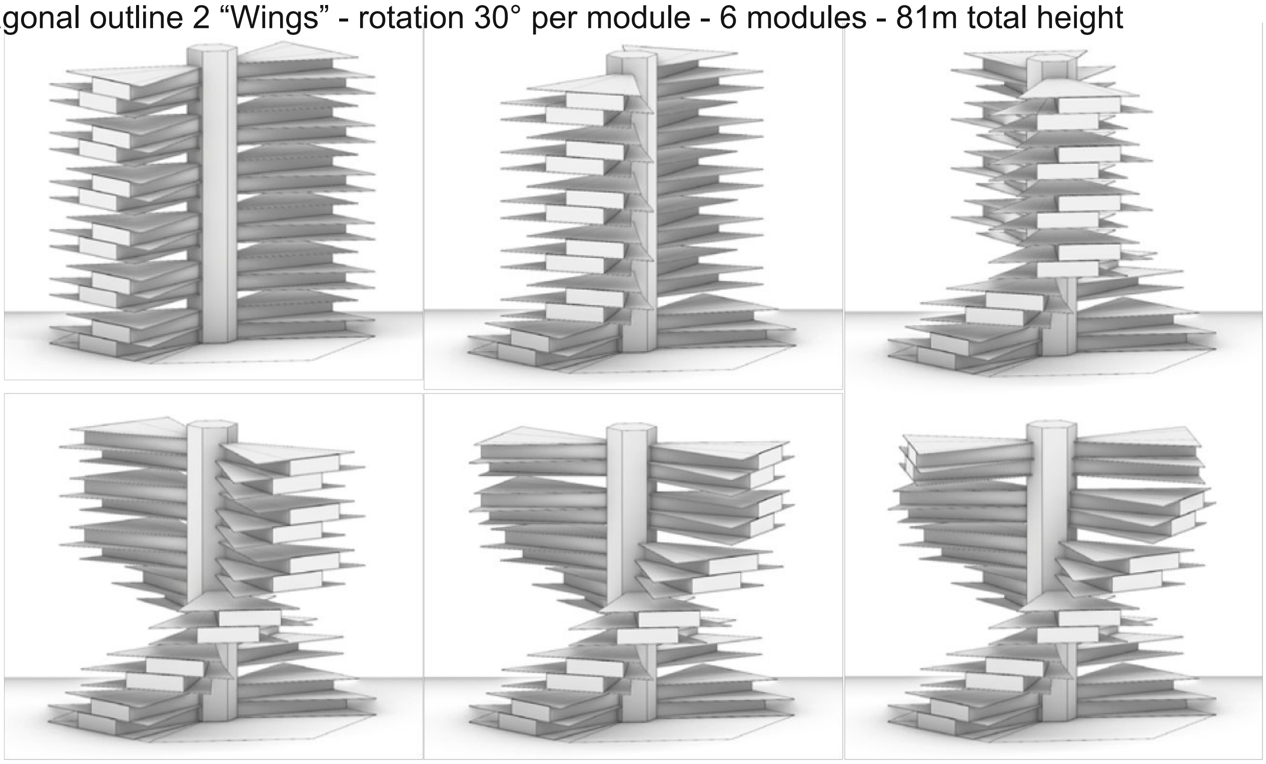
57:
Lifting Up



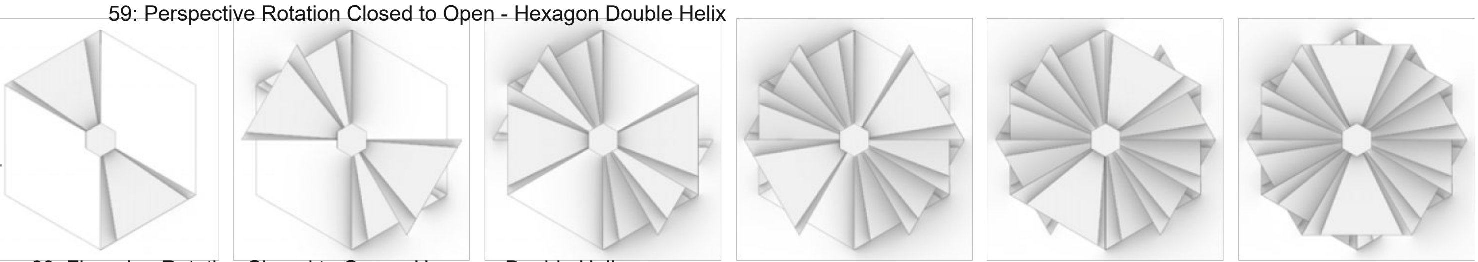
58:
Condense

Concept examination of rotational setups, angle and shape variations to achieve a full helix

Hexagonal outline 2 “Wings” - rotation 30° per module - 6 modules - 81m total height

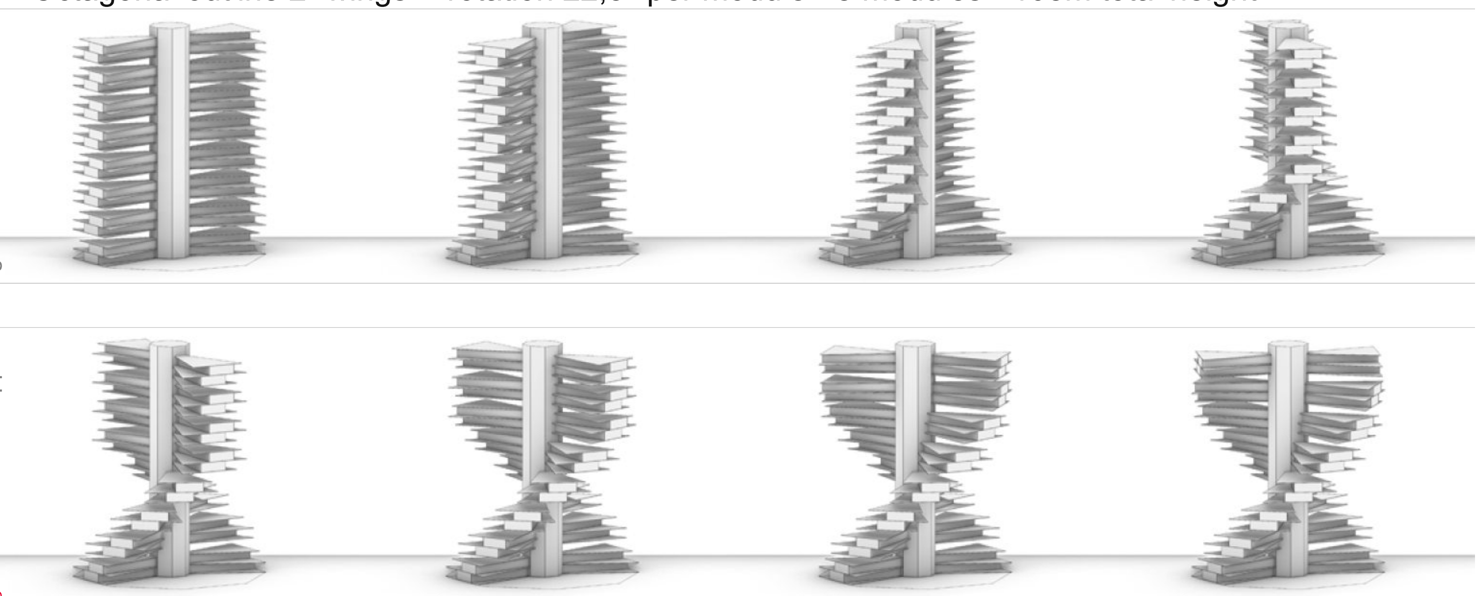


59: Perspective Rotation Closed to Open - Hexagon Double Helix

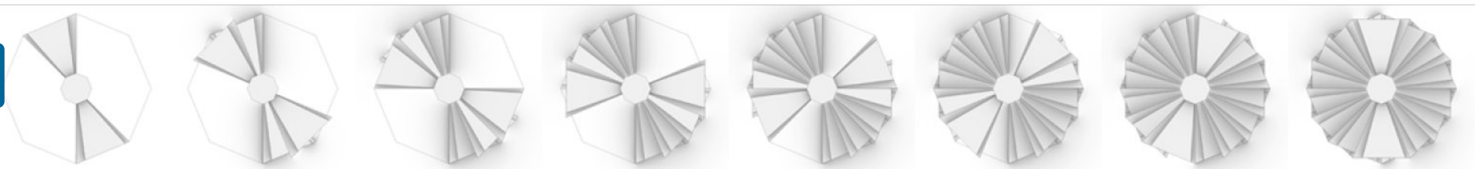


60: Floorplan Rotation Closed to Open - Hexagon Double Helix

Octagonal outline 2 “wings” - rotation 22,5° per module - 8 modules - 108m total height

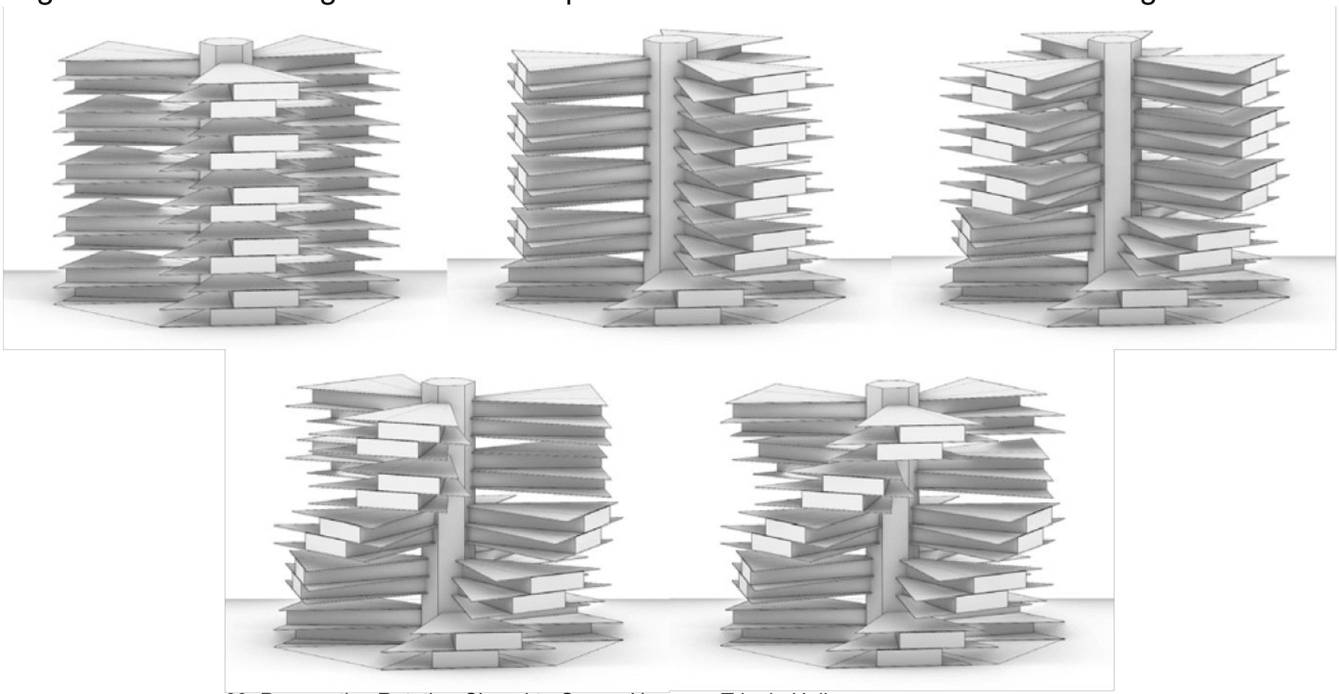


61: Perspective Rotation Closed to Open - Octagon Double Helix



62: Floorplan Rotation Closed to Open - Octagon Double Helix

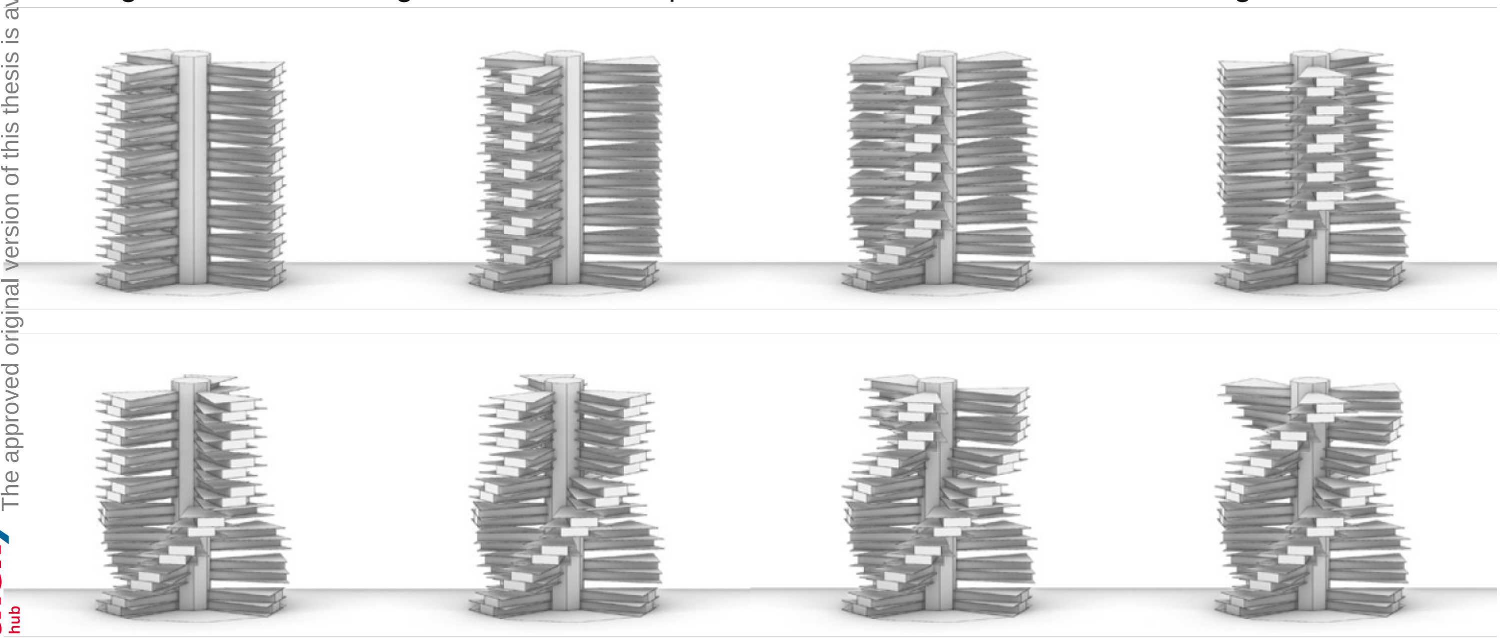
Hexagonal outline 3 “Wings” - rotation 30° per module - 5 modules - 67.5m total height



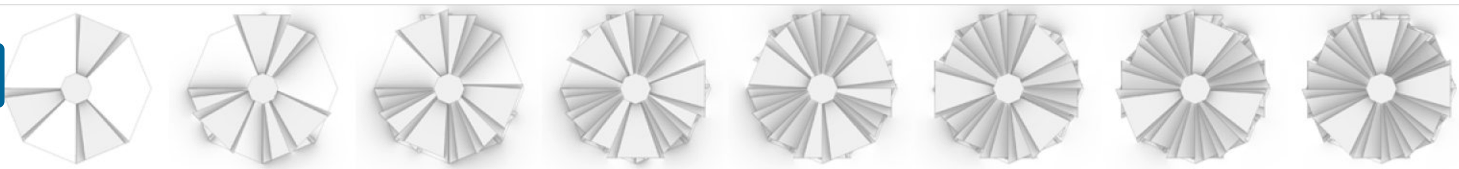
63: Perspective Rotation Closed to Open - Hexagon Tripple Helix

64: Floorplan Rotation Closed to Open - Hexagon Tripple Helix

Octagonal outline 3 “wings” - rotation 22,5° per module - 8 modules - 108m total height

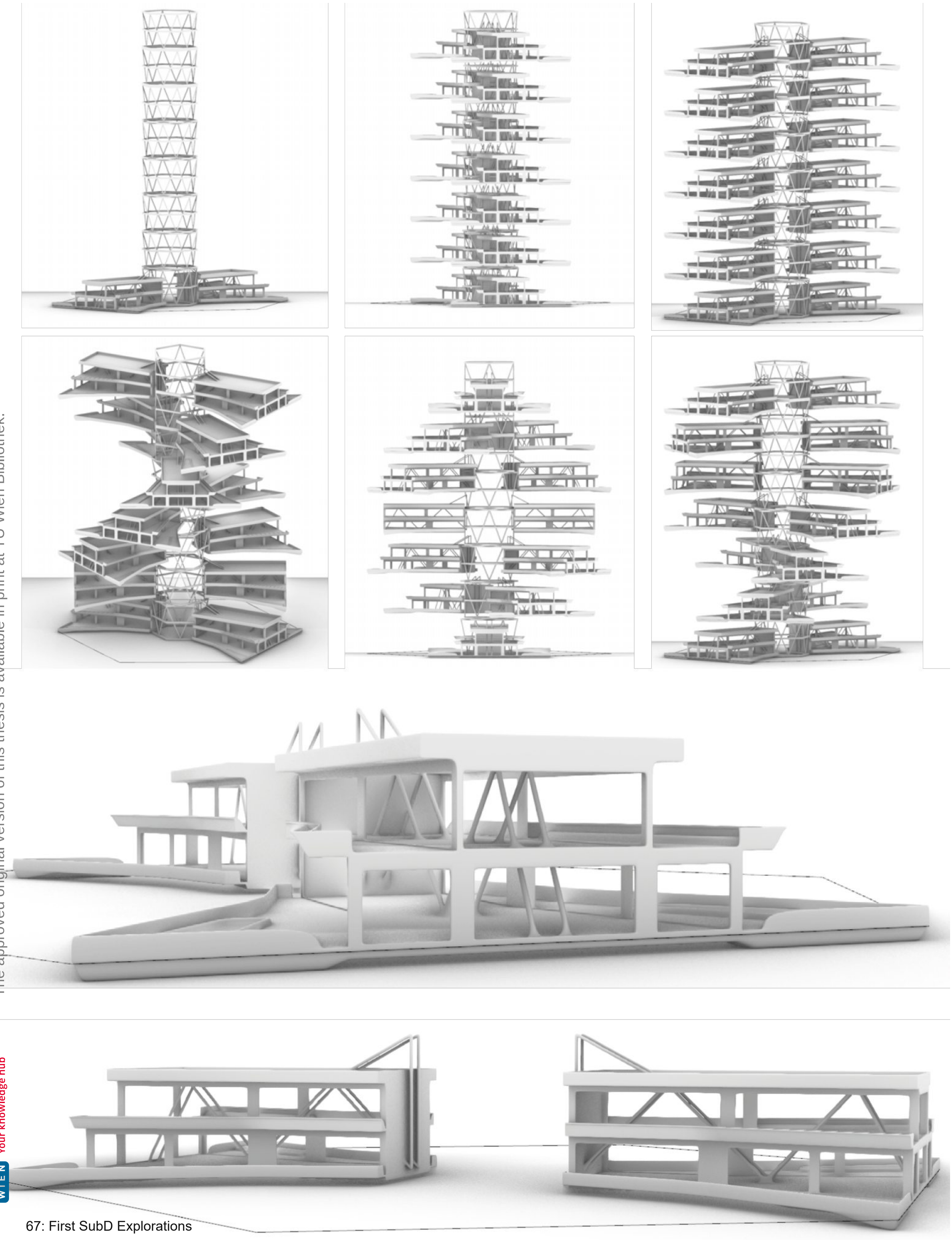


65: Perspective Rotation Closed to Open - Octagon Tripple Helix

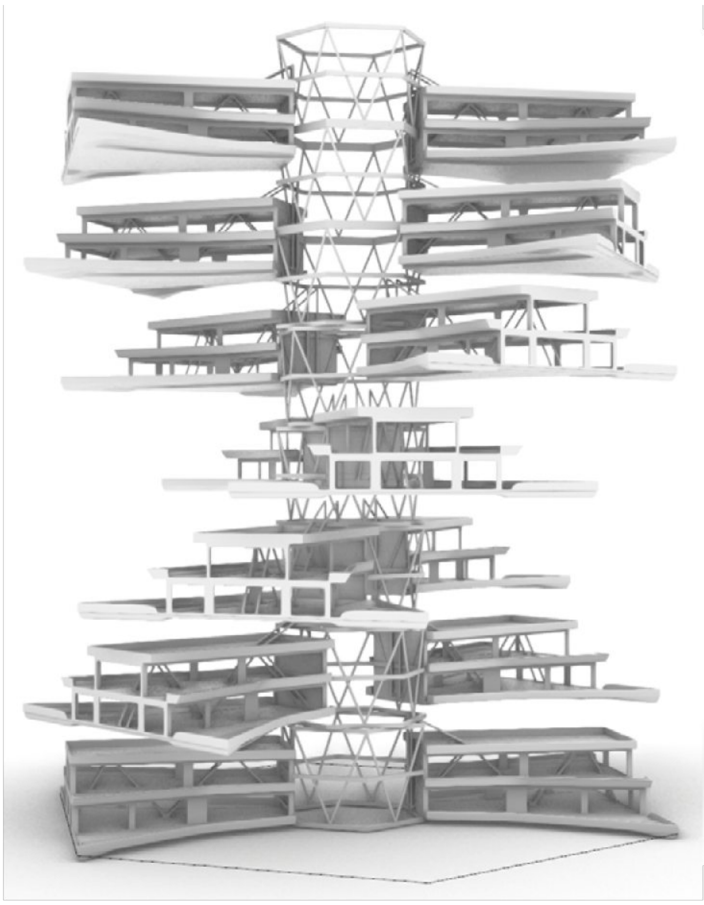


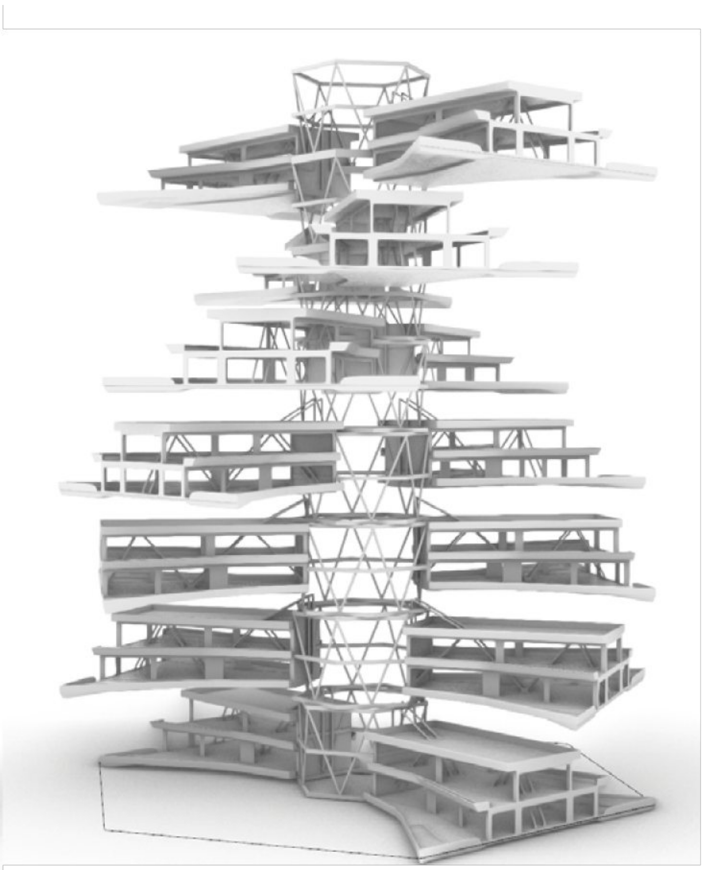
66: Floorplan Rotation Closed to Open - Octagon Tripple Helix

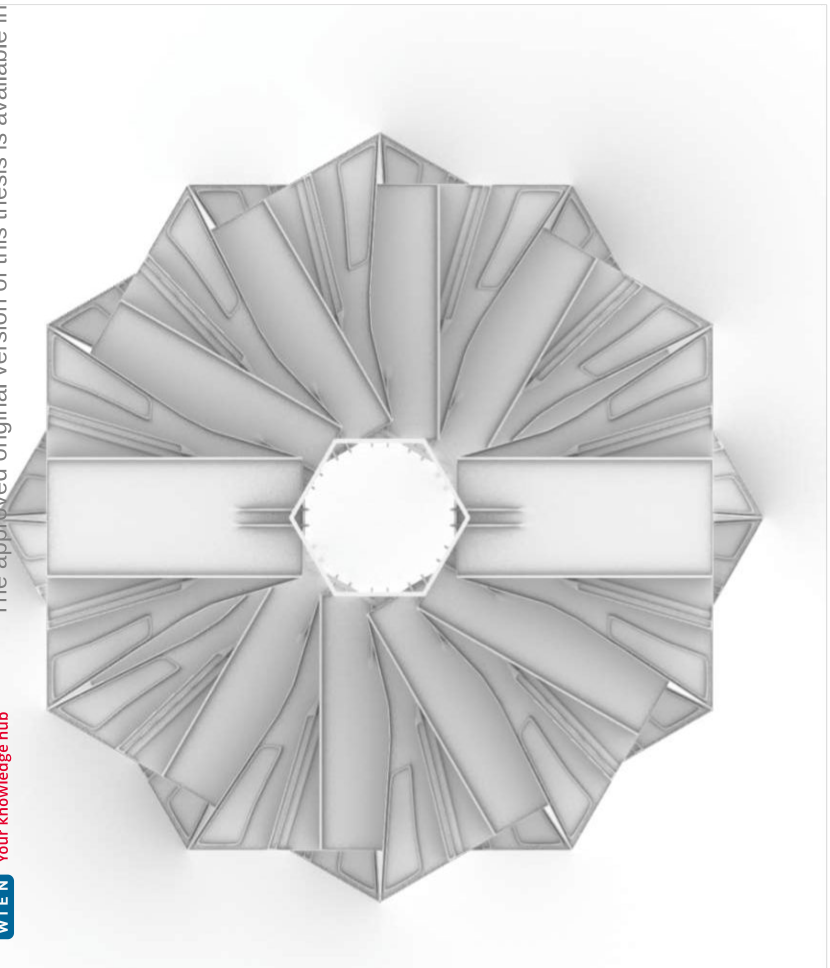
Hexagonal outline 2 “wings” - rotation 30° per module - 7 modules - first facade explorations and contemplations - symmetrical setbacks

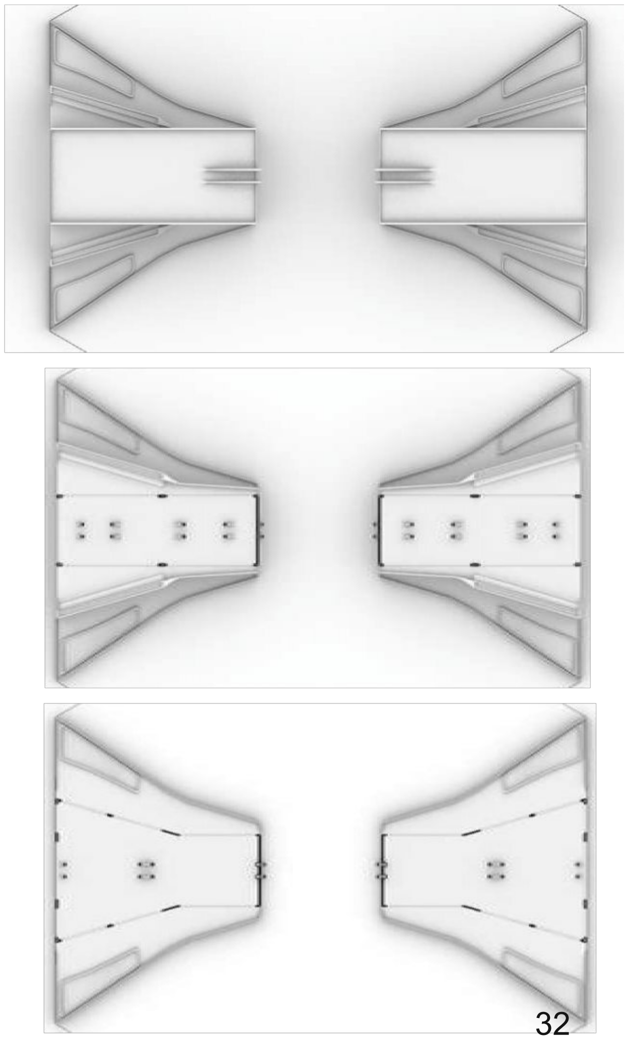


67: First SubD Explorations



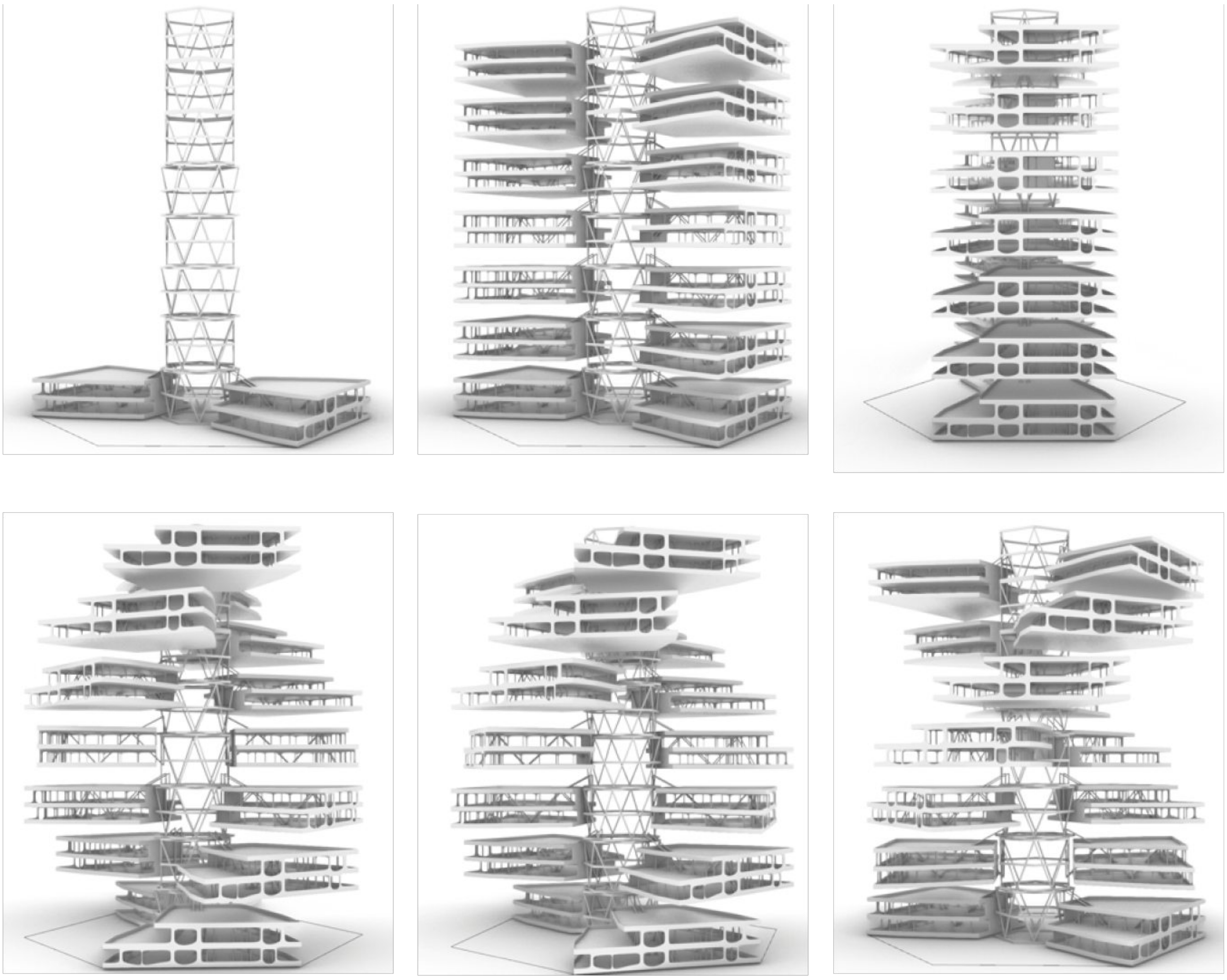


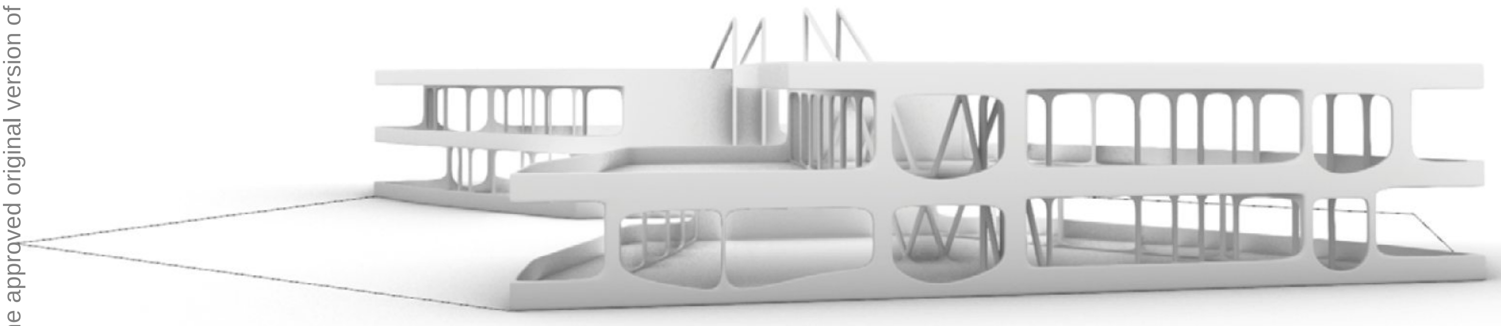


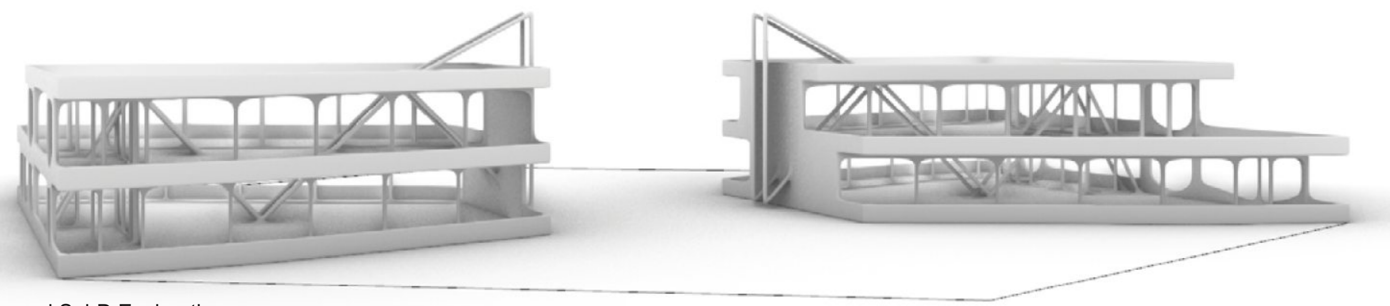


68: First SubD Explorations - Floorplans and Perspectives

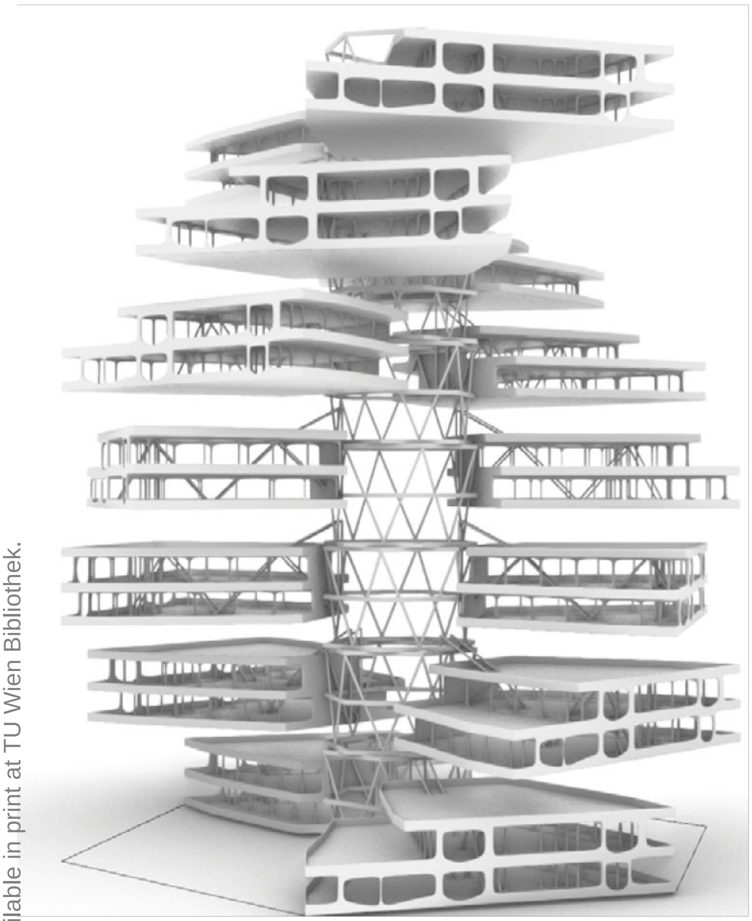
Hexagonal outline 2 “wings” - rotation 30° per module - 7 modules - first facade explorations and contemplations - asymmetrical setbacks

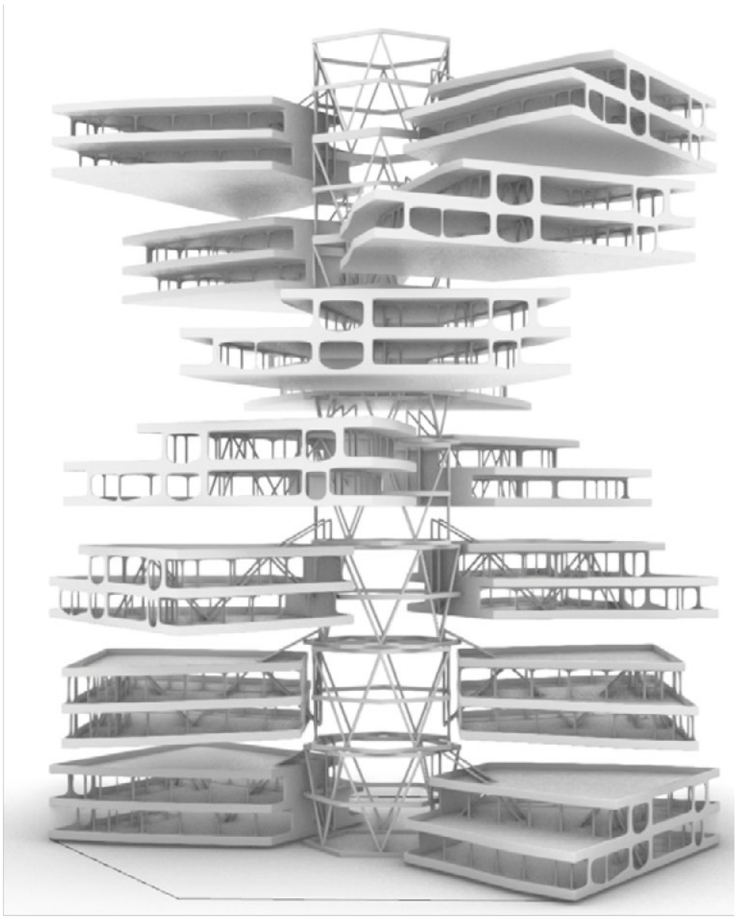


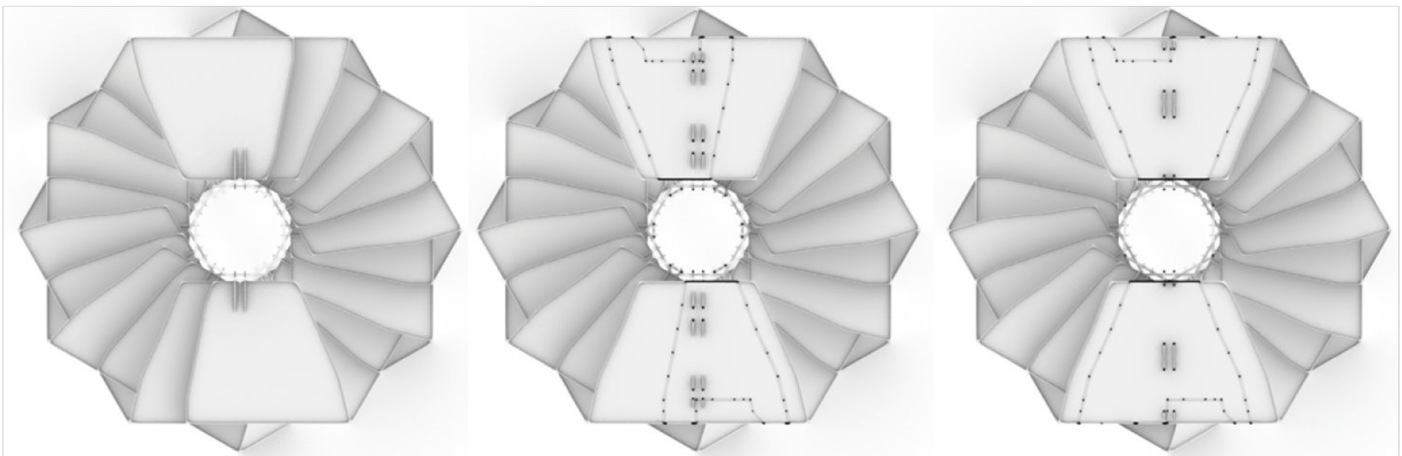




69: Second SubD Exploration

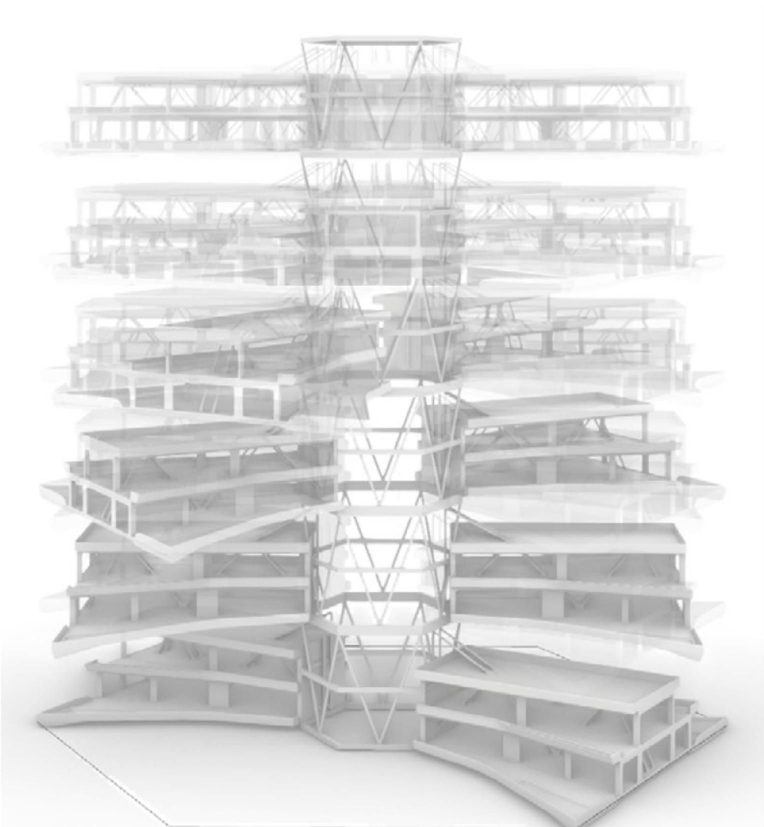






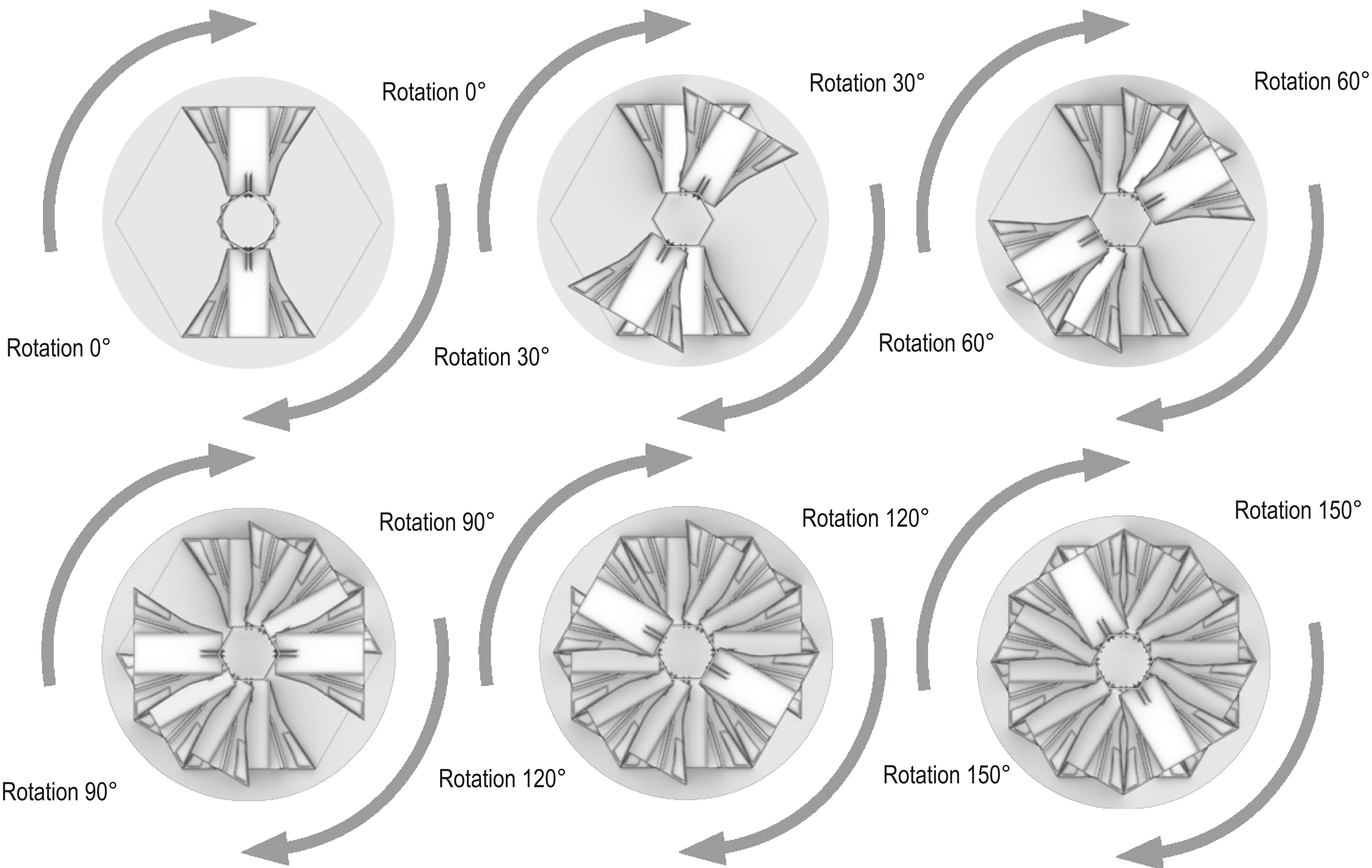
70: Second SubD Exploration - Floorplans and Perspectives

Doublehelix-configuration
Hexagonal floorplan - 6 modules



71: Overlay Rotational Modules in Perspective

At this point of my exploration I was examining a setup based on a hexagonal base shape. Upon initial consideration it became clear that the basic outline defining the design as well as the differenciation between two or three wings would ultimately define the angle of rotation necessary to develope the desired goal of a fully rotating helix that can be achieved with comparable ease and then could be extended vertically basicaly as far as the most recent and advanced technological developments allow.
For the hexagonal base shape with two wings and six rotational modules of three stories each a rotational angle of 30° arises from the mathematical constraints in order to result in shape of the double helix most commonly known from the human DNA.

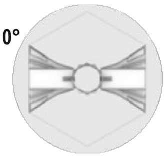


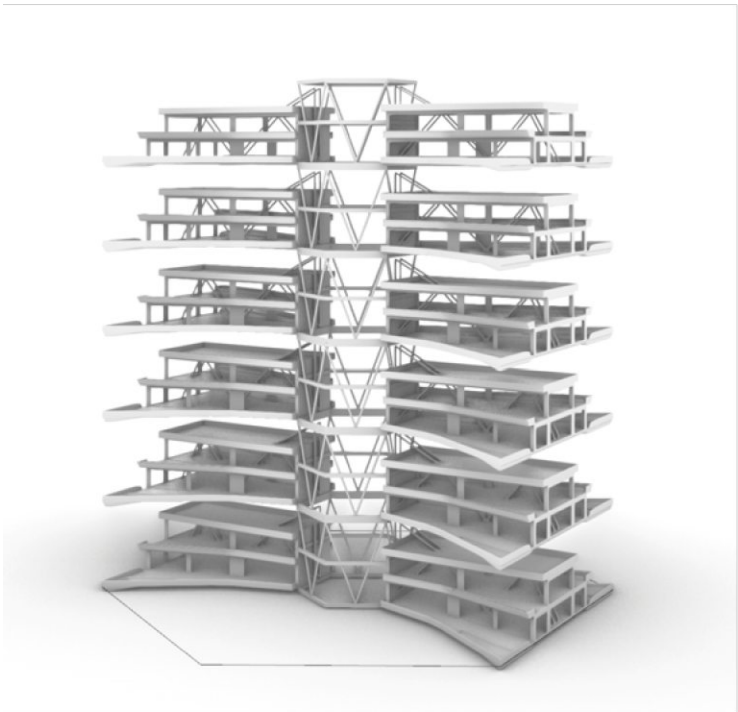
Hexagonal floorplan 2 wings - rotation 30° per module
per rotational unit 6 modules - 150° rotation in the 6. module
with 7. module the new second rotational unit starts at - 180° rotation

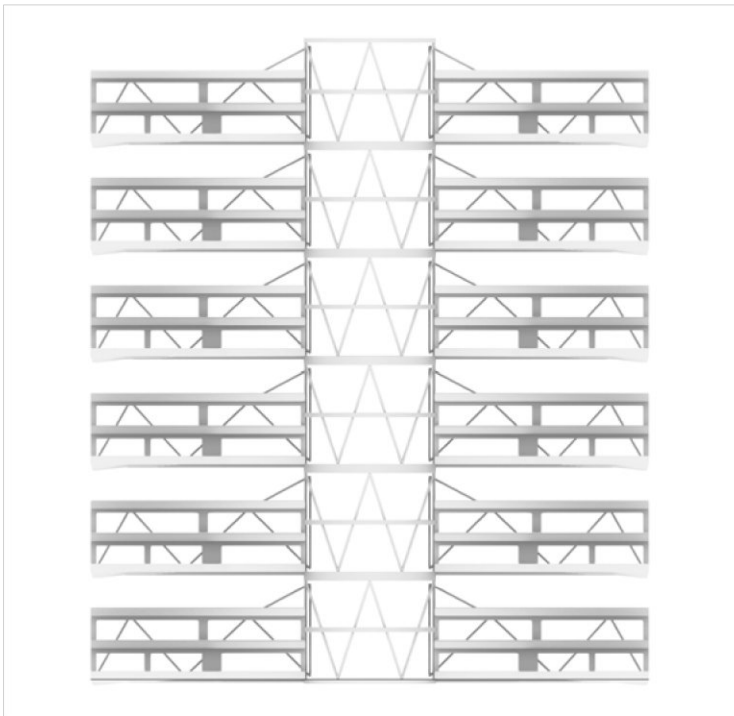
72: Rotational -Explanation Diagram

Hexagonal floorplan rotational unit - 6 Module - 18 Geschosse

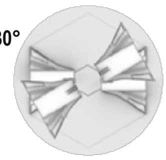
0°

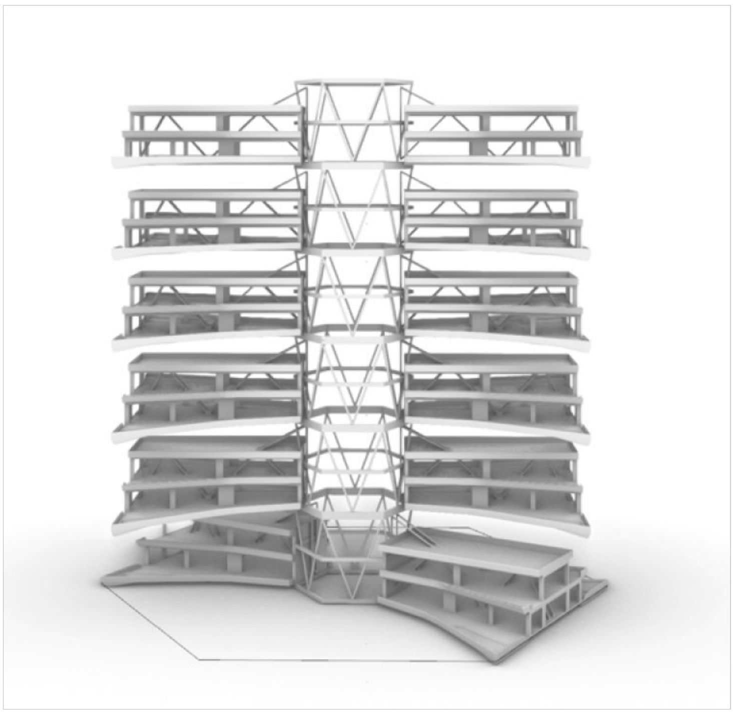


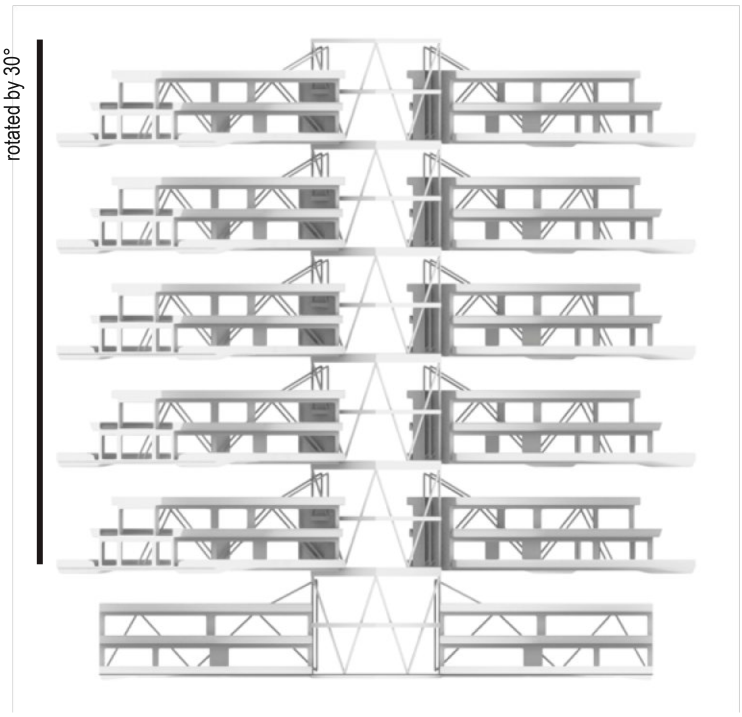




30°

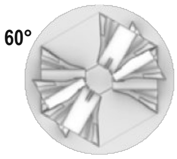


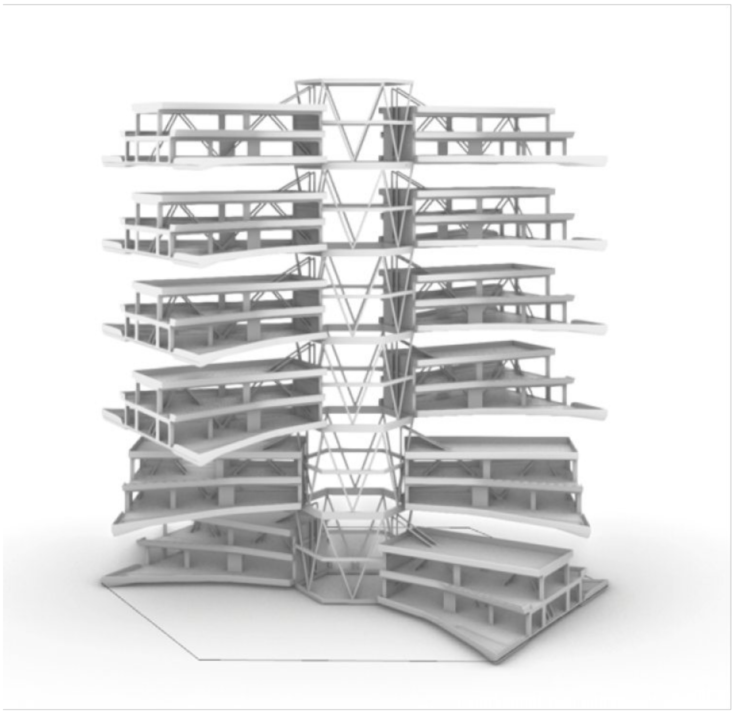


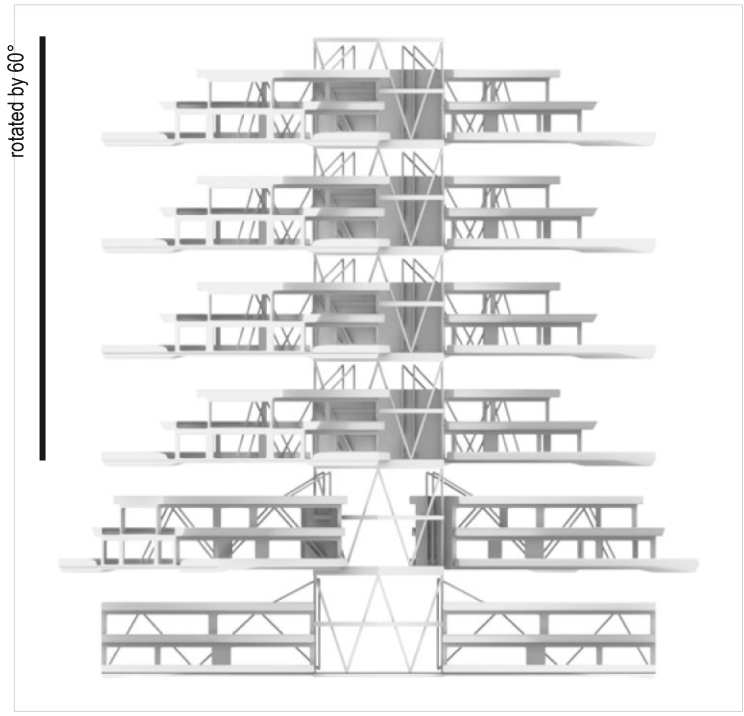


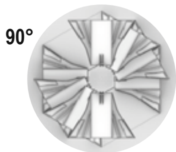
73: Rotational -Explanation Perspective and Elevation - 1

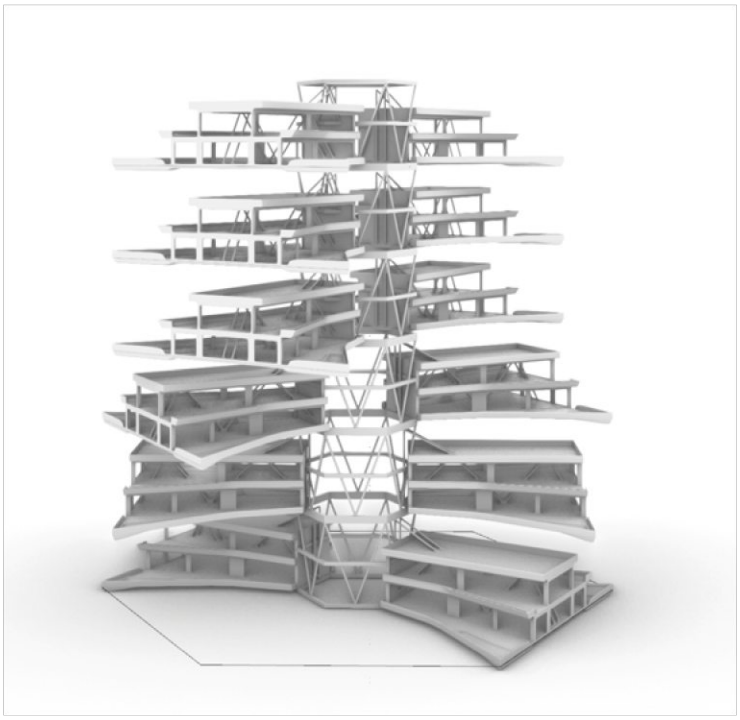
Hexagonal floorplan rotational unit - 6 Module - 18 Geschosse

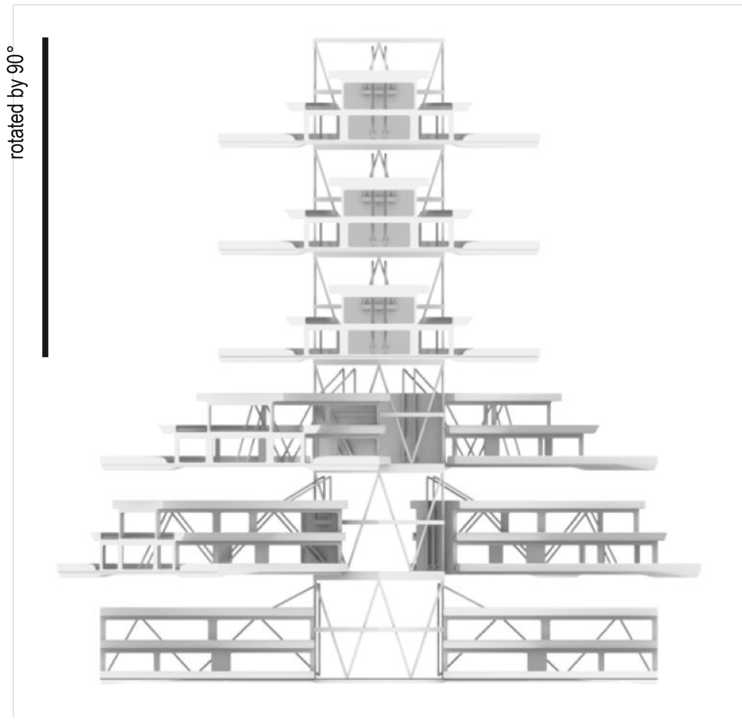




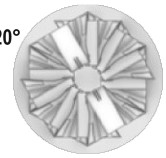


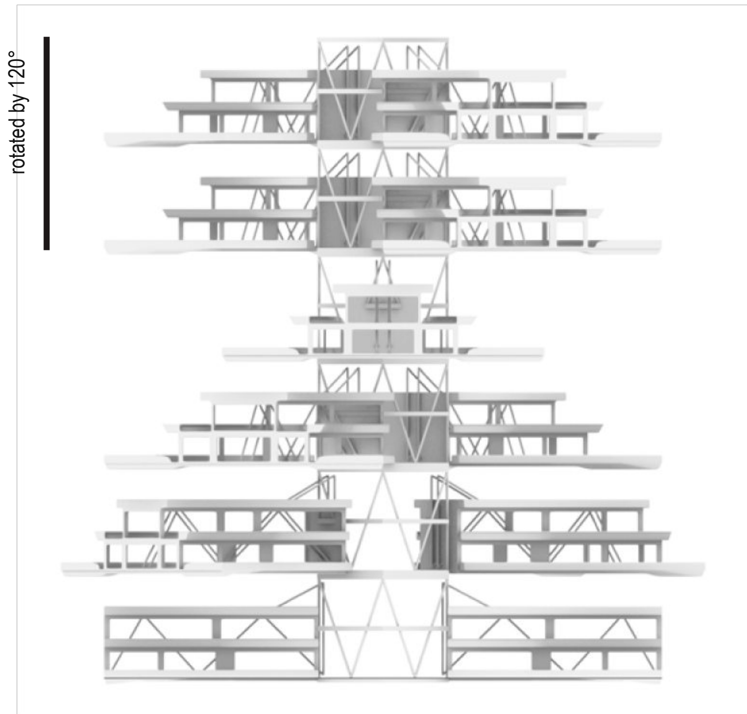


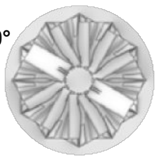


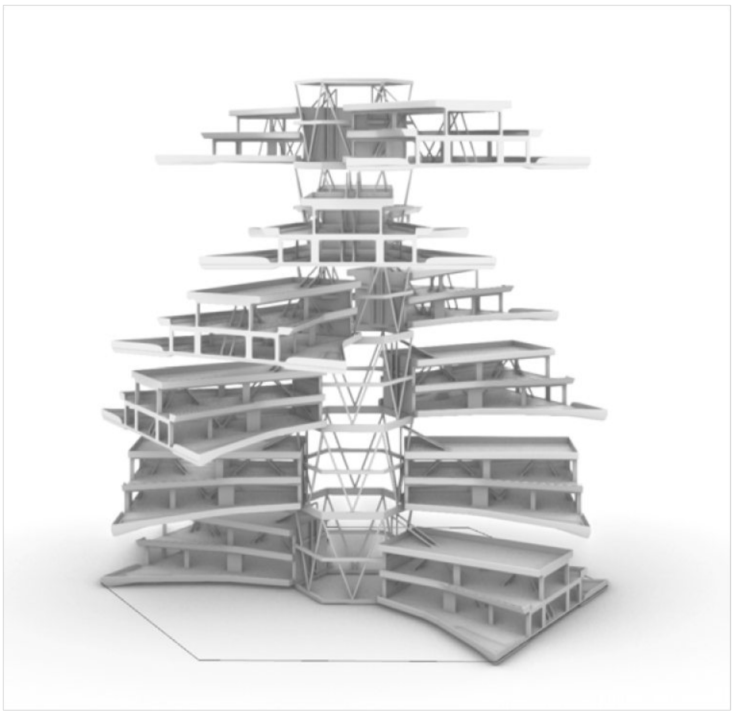


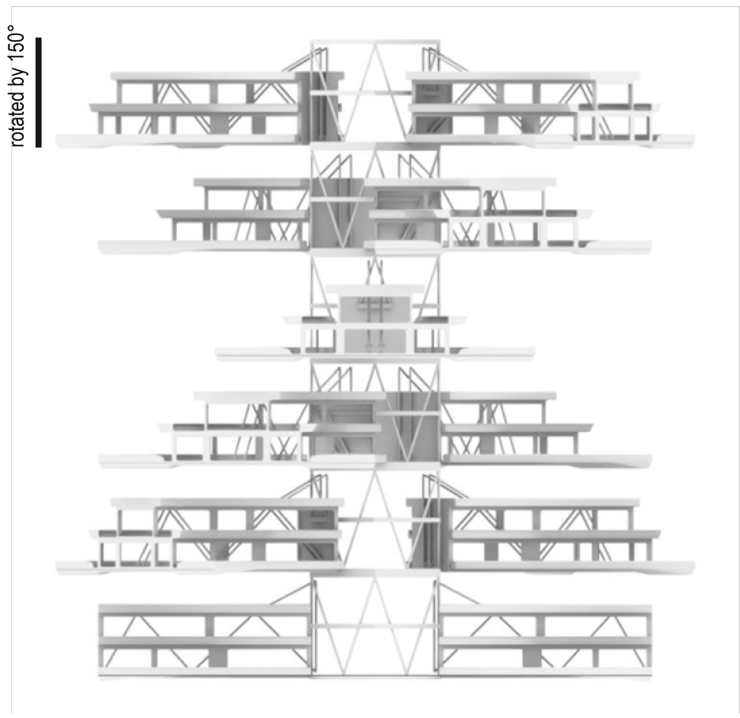
74: Rotational -Explanation Perspective and Elevation - 2





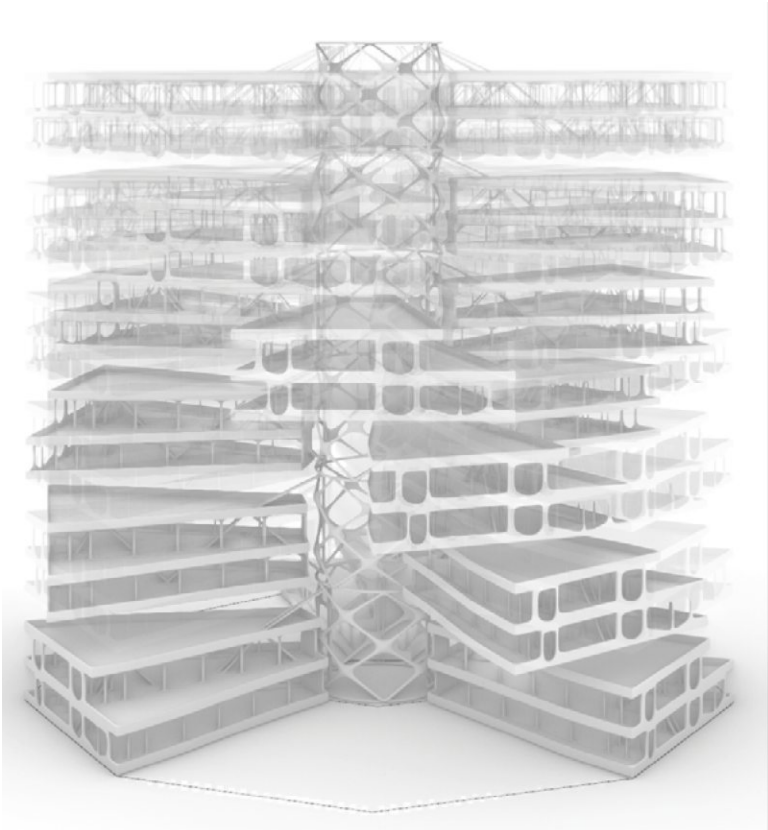






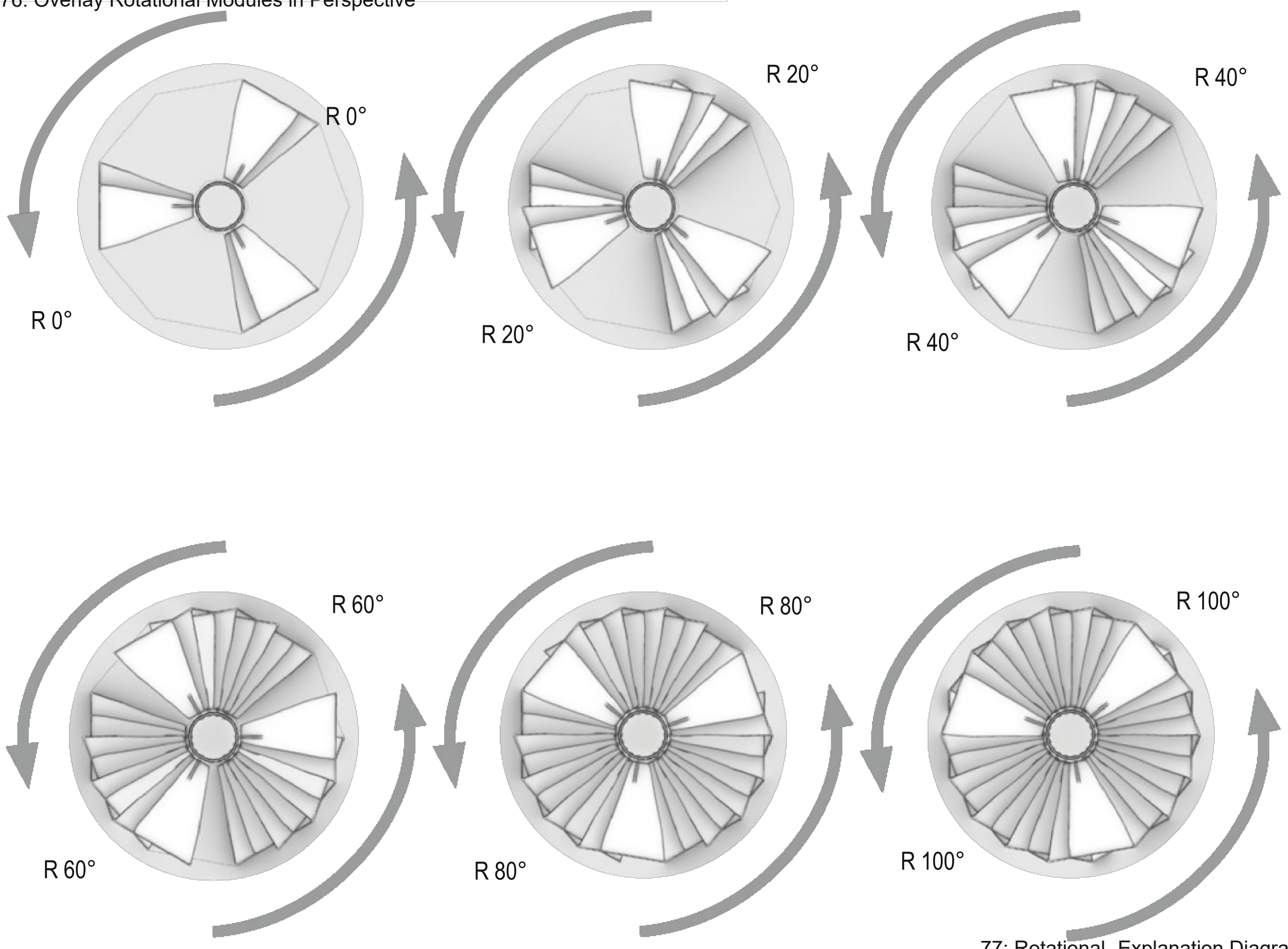
75: Rotational -Explanation Perspective and Elevation - 3

Triplehelix - configuration
Nonagonal floorplan - 6 modules



76: Overlay Rotational Modules in Perspective

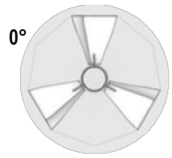
After extensive analysis of the two winged hexagonal design as well as some variations of octagonal typologies (again due to mathematical constraints and aesthetical as well as practical contemplations a certain limitation in variation is given through simple logic) the next step was to compare these shapes to geometrical outlines that would be siutable for a three winged propellor as a base shape. Here as depicted above polygons with numbers of sides divideable by three are advantageous. The most fitting shape turned out to be that of a nonagon (polygon with 9 edges). This provides a lower necessary rotational angle in order to achieve the tripple helix design since the sum of angles necessary to overcome is reduced from 180° in the double edged version to 120° in this iteration.

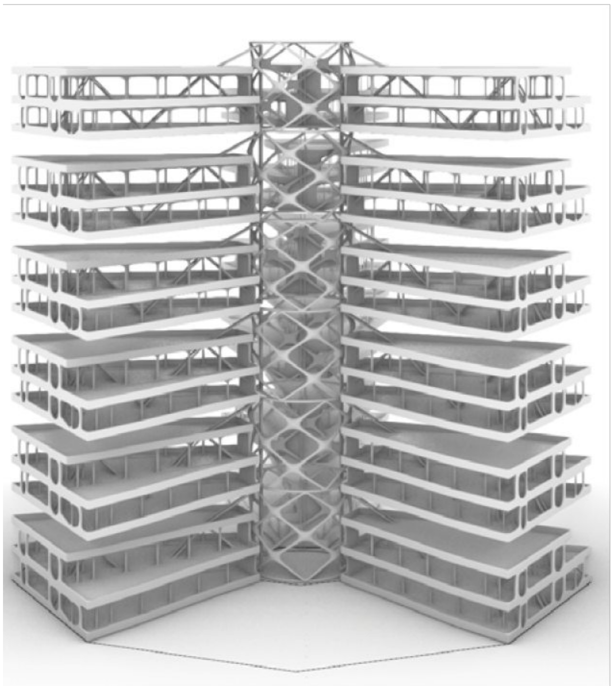


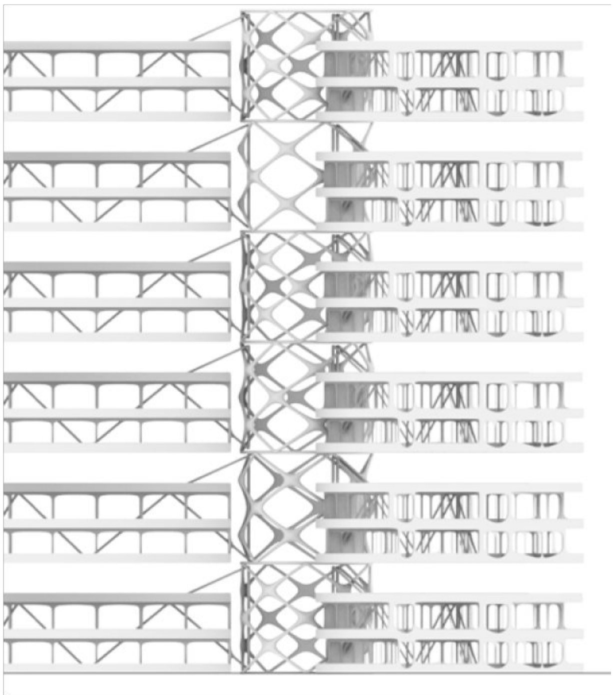
77: Rotational -Explanation Diagram

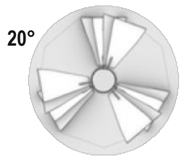
Nonagonal (9-cornered) floorplan 3 wings - rotation 20° per module - per rotational unit 6 modules - 100° rotation in 6. module with the 7. module the 2. rotational unit starts - 120° rotation

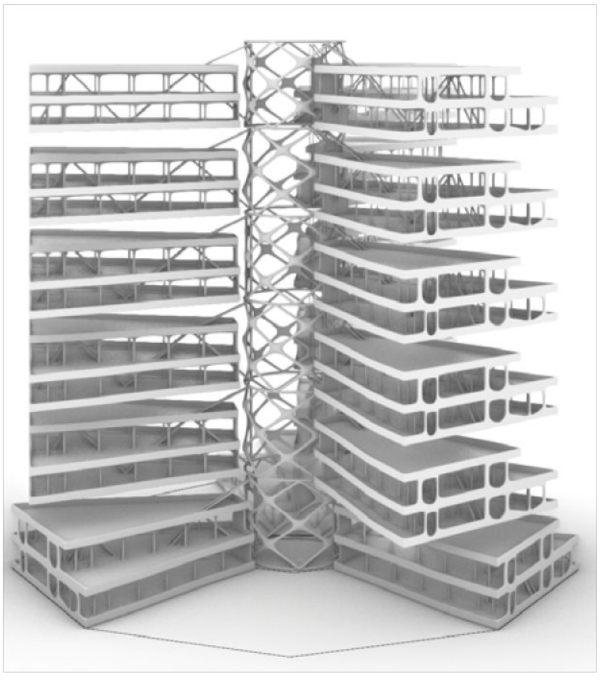
Nonagonal floorplan rotational unit - 6 modules - 18 floors

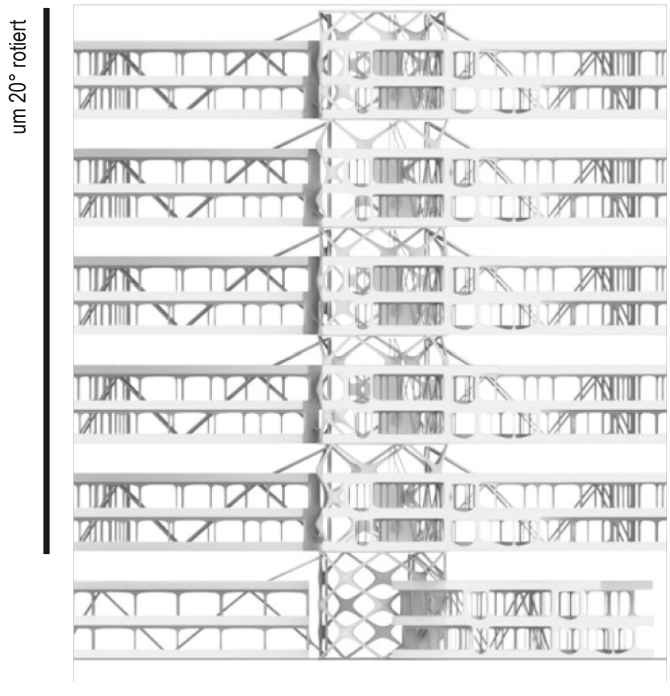






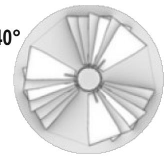


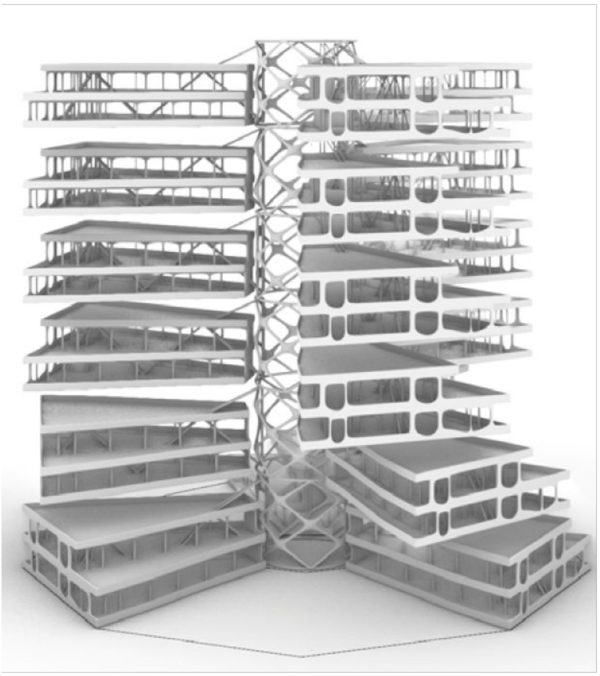


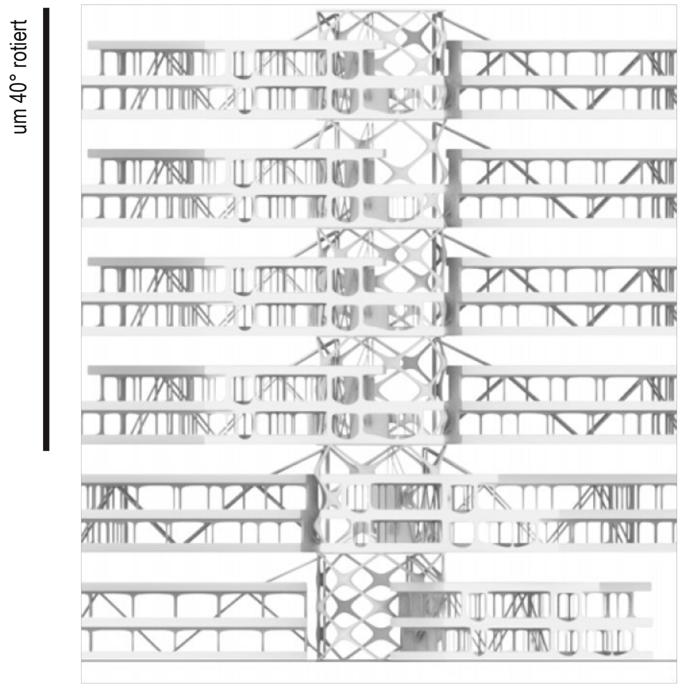


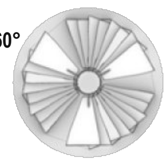
78: Rotational - Explanation Perspective and Elevation - 1 Nonagonal

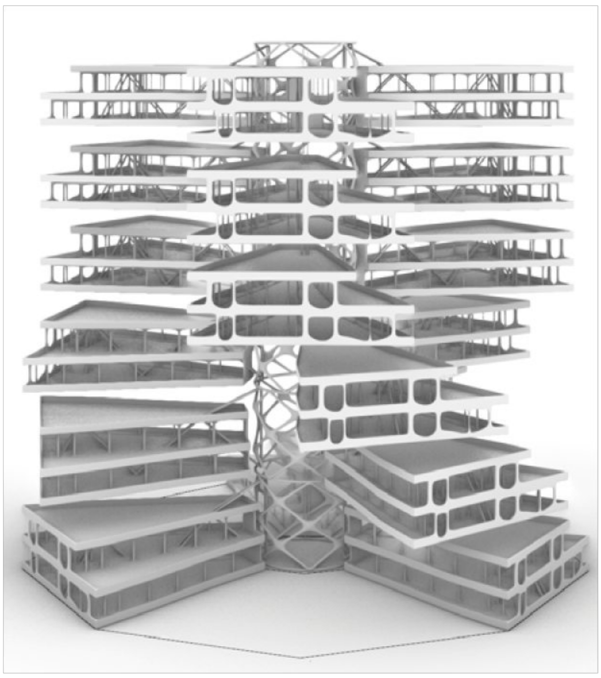
Nonagonal floorplan rotational unit -
6 modules - 18 floors

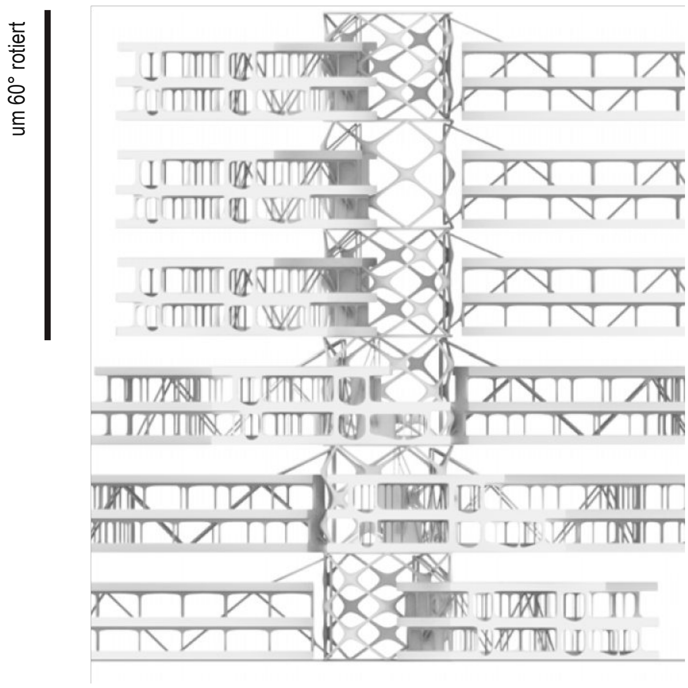




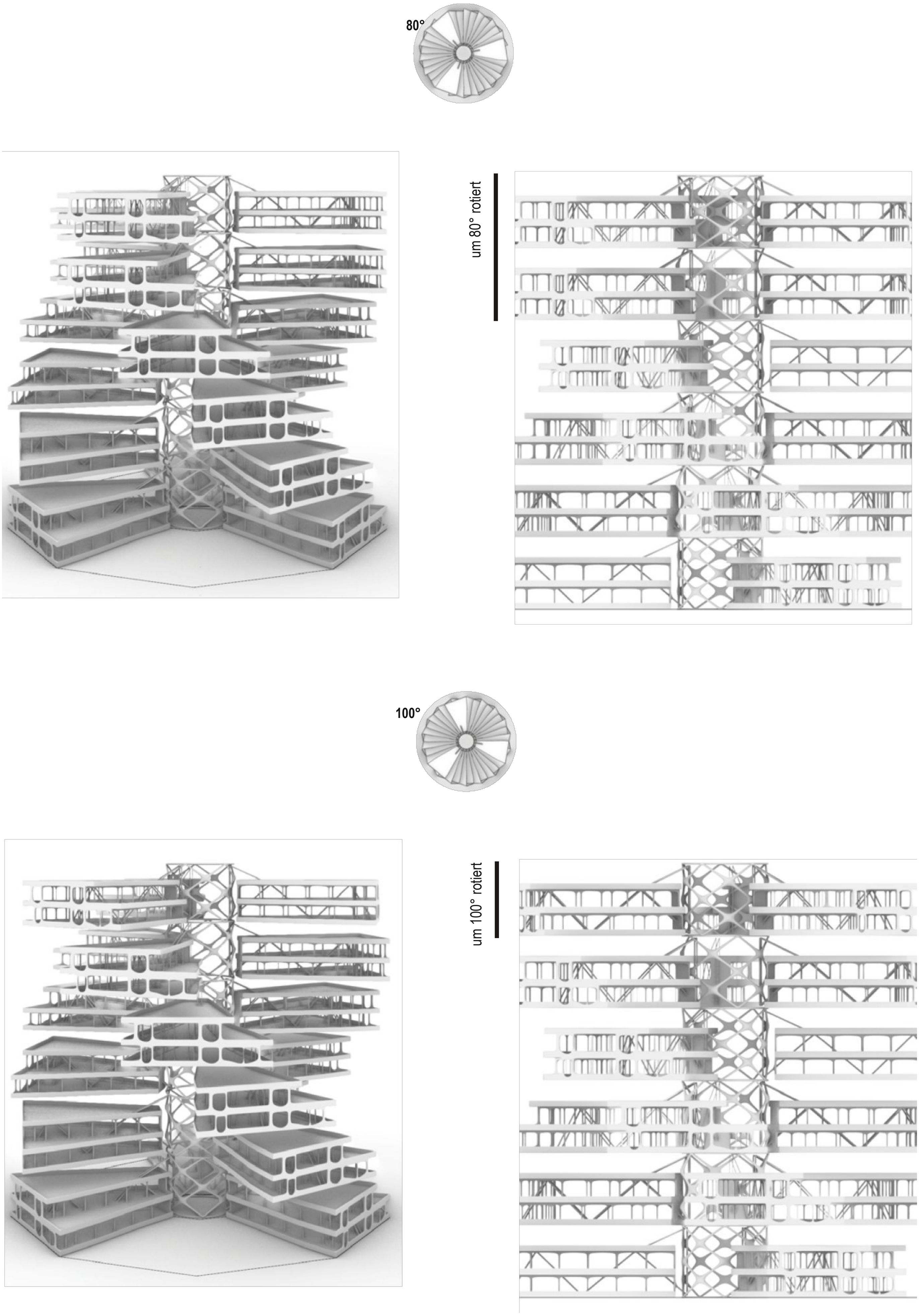








79: Rotational - Explanation Perspective and Elevation - 2 Nonagonal



80: Rotational - Explanation Perspective and Elevation - 3 Nonagonal

4.2 Adabtability

The project aims to not only develop a systematic new construction approach for a state of the art high rise building, but also to propose a new strategy on how to interweave commonly separate tenants and use-cases in one unifying structure. The idea is to provide a spacial organization, that can ideally adapt to basically any given site and desired spacial programming through combination of spaces from office spaces to recreational park areas all accessible from the central circulation core. To achieve this a system has to be created which is capable of facilitating the various technical and social requirements given in various spaces. As the plumbing needs vary immensely between office spaces dwelling units and outdoor areas so do the accumulating masses depending on the structural module being designed to provide living quarters for people or the necessary natural conditions i.e. soil, wind protection or artificial water supply to enable a variety of plants from ferns over bushes all the way to small or medium sized trees to grow within the built environment.

The need for an adaptable methodology of skyscraper design is shown in many cities after the pandemic has changed the way millions of people live their lives. A huge amount of commercial office high-rises in the largest metropolitan areas around the world has turned into ghost offices with no tenants left to use or need the space. The reasons for this are diverse, be it the companies that didn't manage to survive the crisis and had to cease operations altogether or just modern companies adapting their office structures in order to meet their employees desire for remote work.

With these giant office buildings now empty the burning question arises: What to do with these often poorly aged remains of the status symbols from the last century? And how to create future structures that won't become obsolete within decades even though it is virtually impossible to reliably predict the needs society will develop with the changes in technology and society progressing at an ever increasing pace.

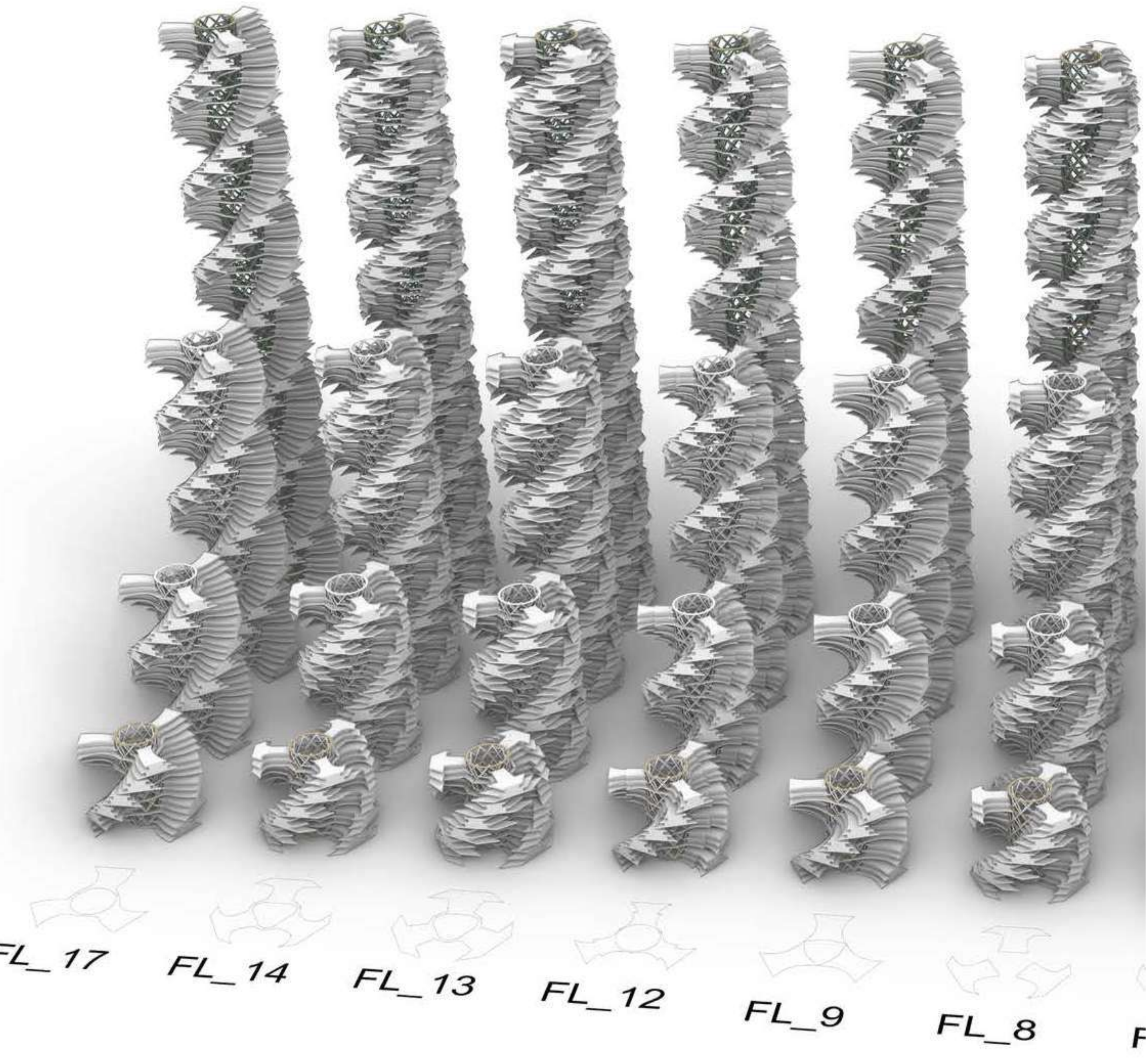
The former question will serve rather as a guideline whereas the later one will be adressed in this thesis. Since it won't be possible to list all the different possible use cases and elaborate on specific design proposals for all the tenants only some of the classical scenarios will be explored and compared to more atypical spacial programs especially considering traditional skyscrapers. The typologies that will be studied in the devolpment of this sustainable vertical habitat will be: Apt spaces varying in size to accomodate different living situations as well as different social groups. Notably all dwelling units will be provided with acces to private, semi private and public open spaces situated within the tower, besides these apt spaces flexible office modules will be provided in an appropriate number and will be designed with a flexible system of appliances provided to facilitate from 1 to 4 different organizations on a single level. To explore some more innovative uses the planing will prove that spaces within the design will be able to facilitat various pools, movie theaters - that can be used as auditoriums and eventspaces alike and all in close relation to a well organized and extensively vegetated exterior spaces and landscapes.

Besides these different use cases the high degree of adaptability not only in the use of spaces but also in the unlimited possibilities for different configurations of sustainable technological implementations are major contributors to the superior quality of this highrise development. Through relatively easy analysis of site conditions like sunlight hours, percipation levels and most common wind directions and average wind speeds, adaptations of the system can be finetuned during a short planing period in order to ideally utilize natural occuring energy potentials.
The atmospheric conditions are no longer considered an opposing factor to the pursued comfort within the building. As opposed to historical build environments these factors become integral part of the designprocess in order to acchieve a much more resilient and future proof architecture.

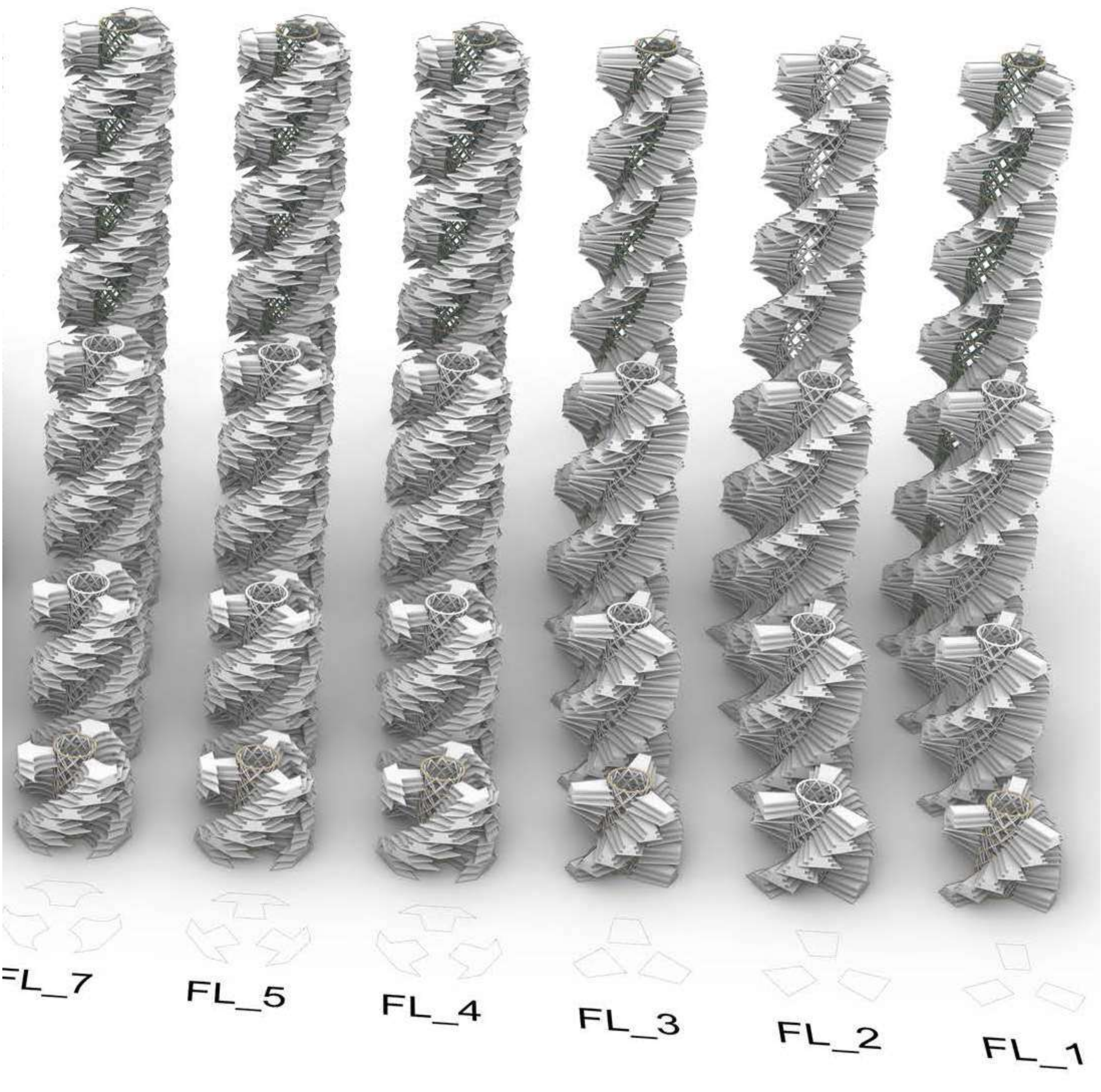
The buildings adaptability is further enhanced through the fact that it can be operated in two completely different states. of appearance. On the one hand fully open - presenting itself with the greatest possible exposure to capture and utilize sunlight and rainwater but also a very large surface area for wind forces to apply. On the other hand fully closed - this configuration reduces the buildings exposure to elements and sunlight drastically.
This option can be utilised if necessary in strong storms or to heavy rains that might run risk of overwhelming the buildings capacities for energy generation, wind resistance or water absorbtion otherwise.
Through the elaborate design of the buildings shape and the capability to rotate the ideal adatation to weather and site can be achieved. With slight calculations and a little finetuning the buildings rotation can further be set up to change throughout the year following the ideal orientation towards the sun in order to maximize solar gains.

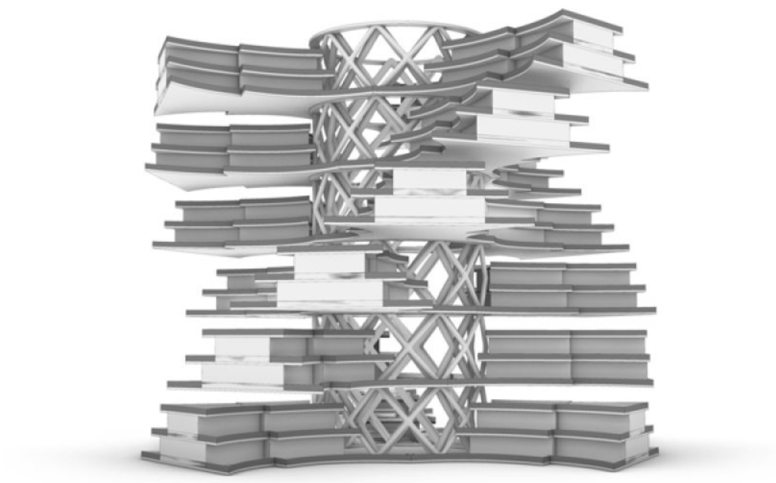
4.3 Formline Variations - Rotational Concept Confirmation and Windtunel Analysis

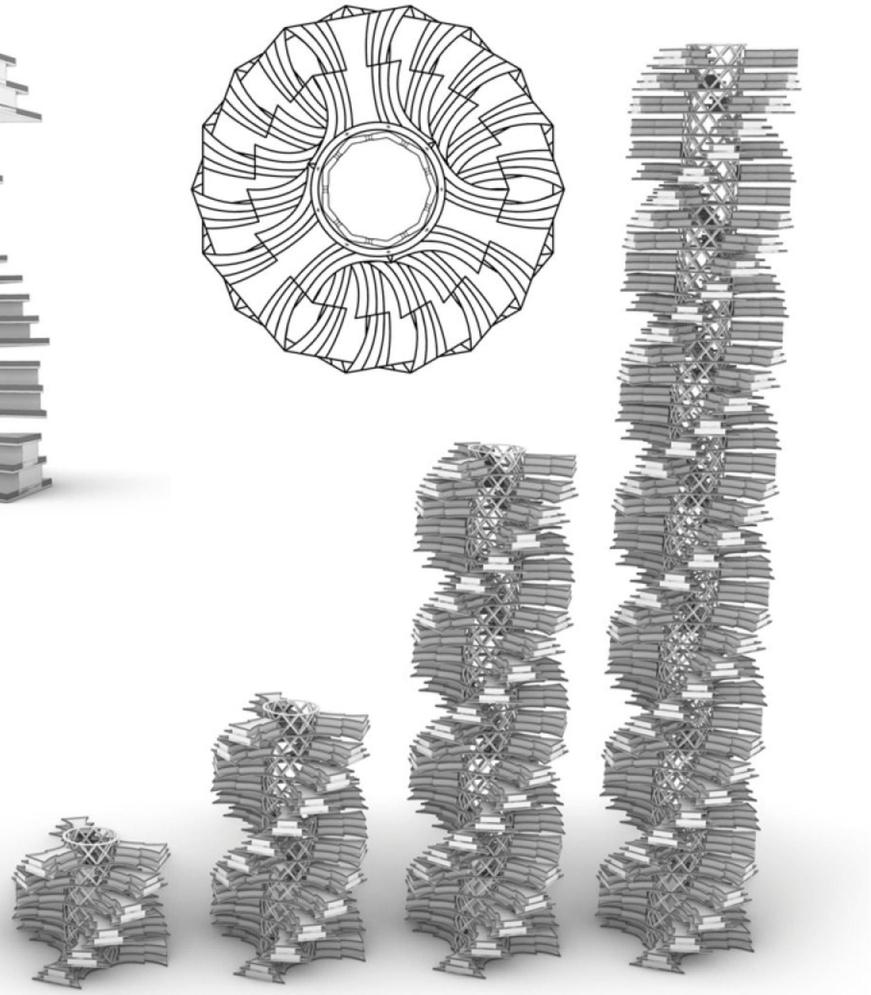
After the confirmation of the rotational and adaptable concept thus far were implemented I proceeded to elaborate on the actual form giving curves within the greater outline to define a shape that can facilitate all the requirements and need defined previously within the goals and challenges of the design. In order to be able to analyse and evaluate many different building typologies the following explorations were conducted with the help of the Grasshopper Plugin inside Rhino in further combination with many other very capable and powerful plugins enabling architects to design in a much more informed manner then it would be at all feasable in the framework setup by traditional methods. The most notable plugins in use for this subchapter of the thesis were Blue CFD core - windanalysis as well as Elefront and Humana plugins in order to speed up and simplify the data management aspects of this evaluation.



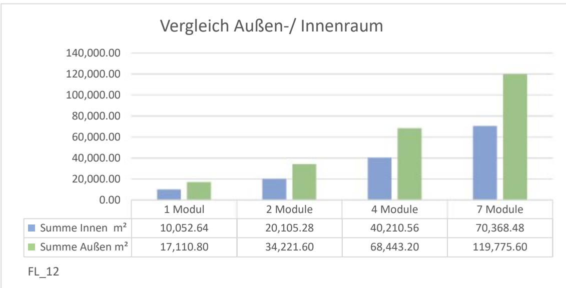
81: 12 Volumetric Studies


FL_7
FL_5
FL_4
FL_3
FL_2
FL_1





preliminary area comparison - outdoor and indoor spaces form line #12

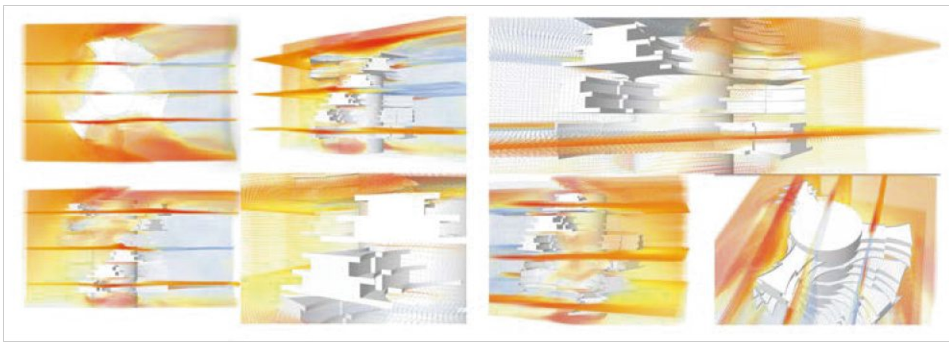


	1 Modul	2 Module	4 Module	7 Module
Summe Innen m²	10,052.64	20,105.28	40,210.56	70,368.48
Summe Außen m²	17,110.80	34,221.60	68,443.20	119,775.60

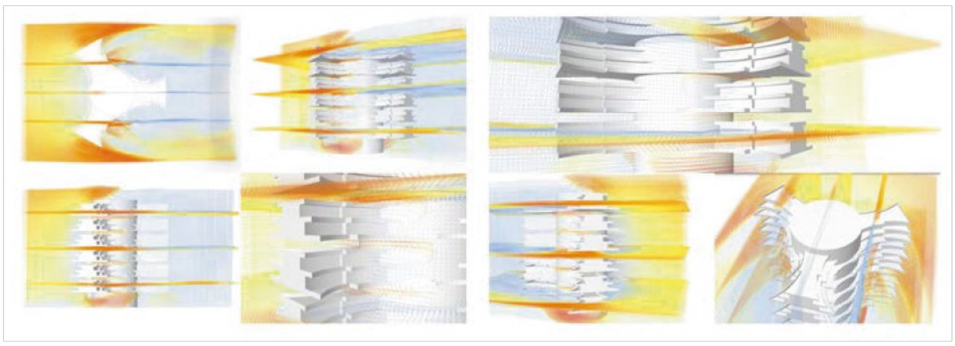
82: Volumes and Area V1

Windtunel - formline #12

FL_12_open_Wind direction in X axle

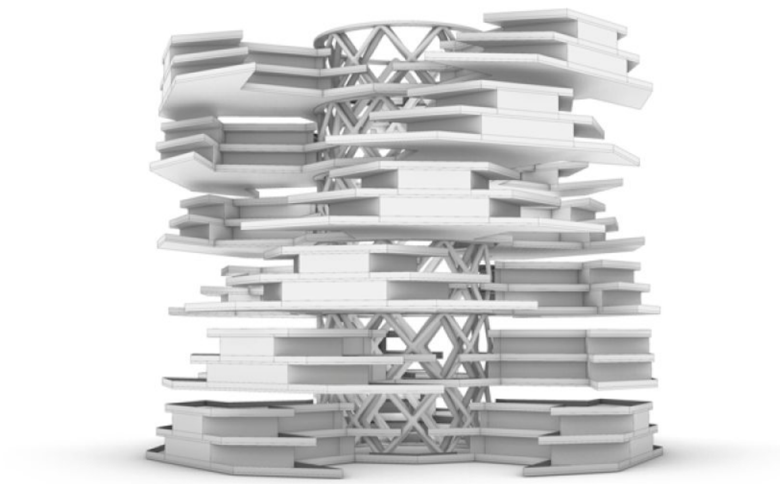


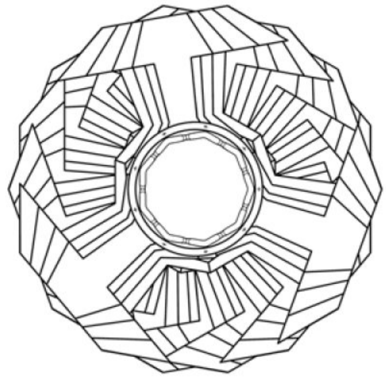
FL_12_closed_Wind direction in X axle



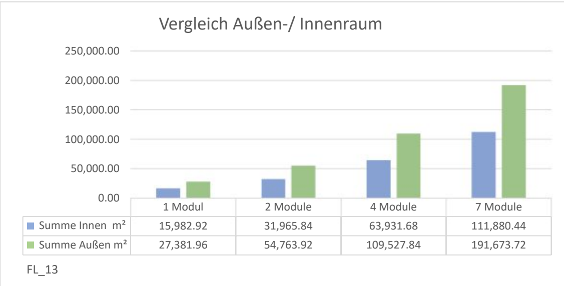
FL_12_closed_Wind direction in negative X axle

83: Windtunnel Analysis V1





preliminary area comparison - outdoor and indoor spaces form line #13

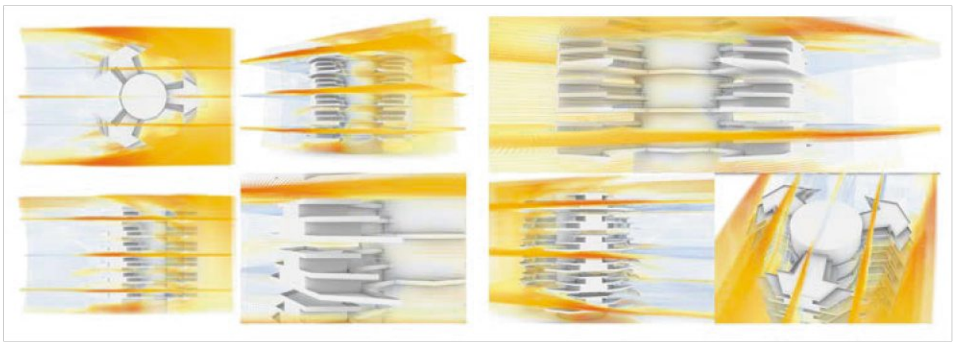


84: Volumes and Area V2

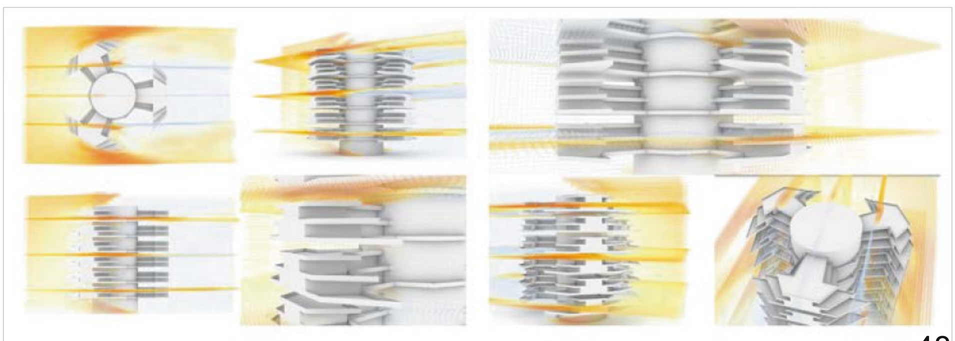
Windtunel - formline #13

FL_13_open_Wind direction in X axle

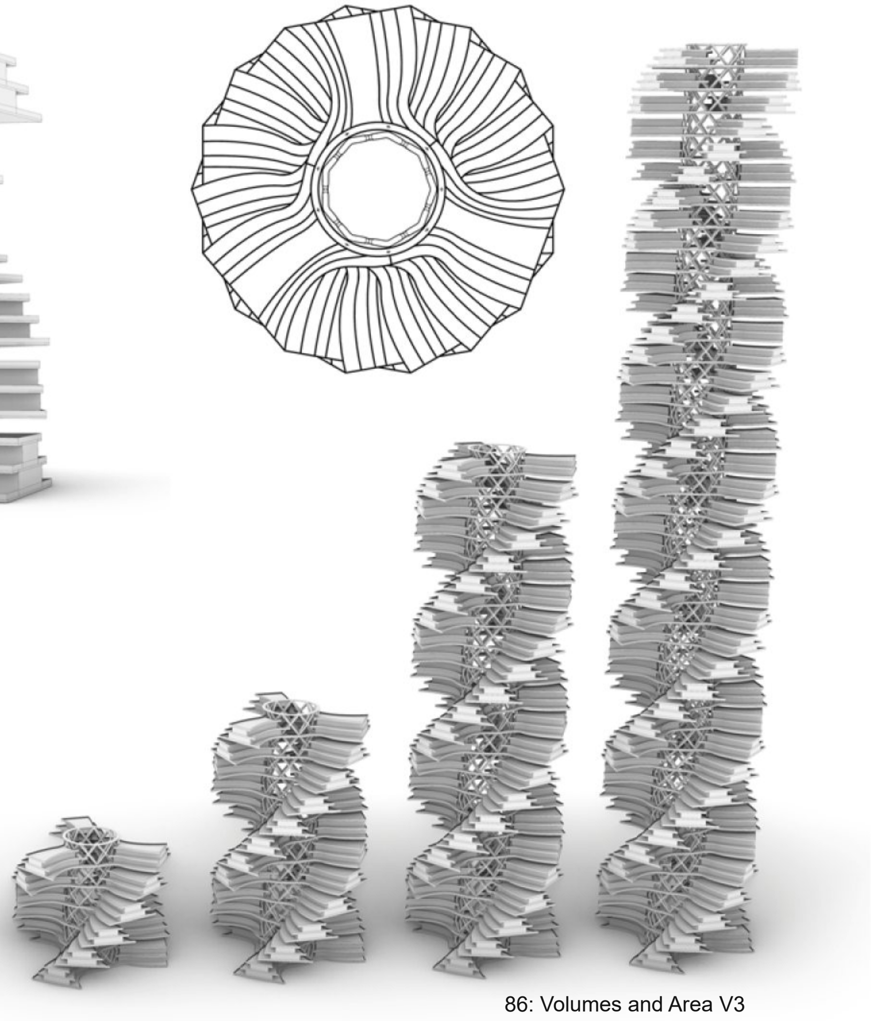
FL_13_closed_Wind direction in X axle



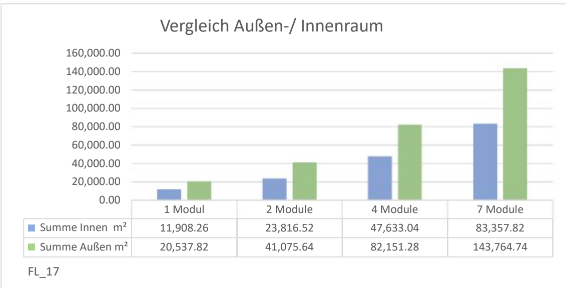
FL_13_closed_Wind direction in negative X axle



85: Windtunnel Analysis V2



preliminary area comparison - outdoor and indoor spaces form line #17



86: Volumes and Area V3

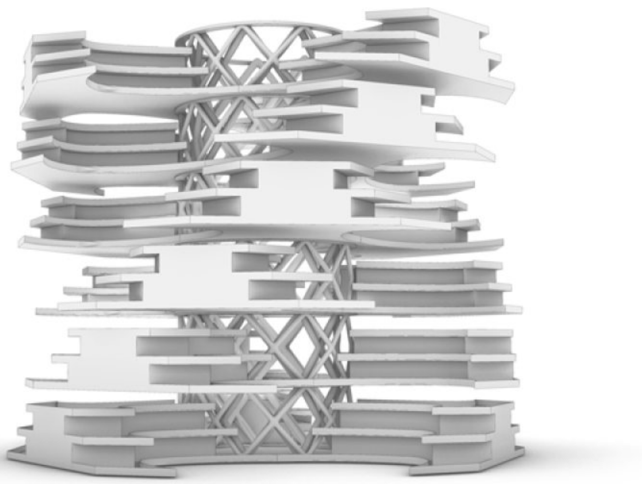
Windtunel - formline #17

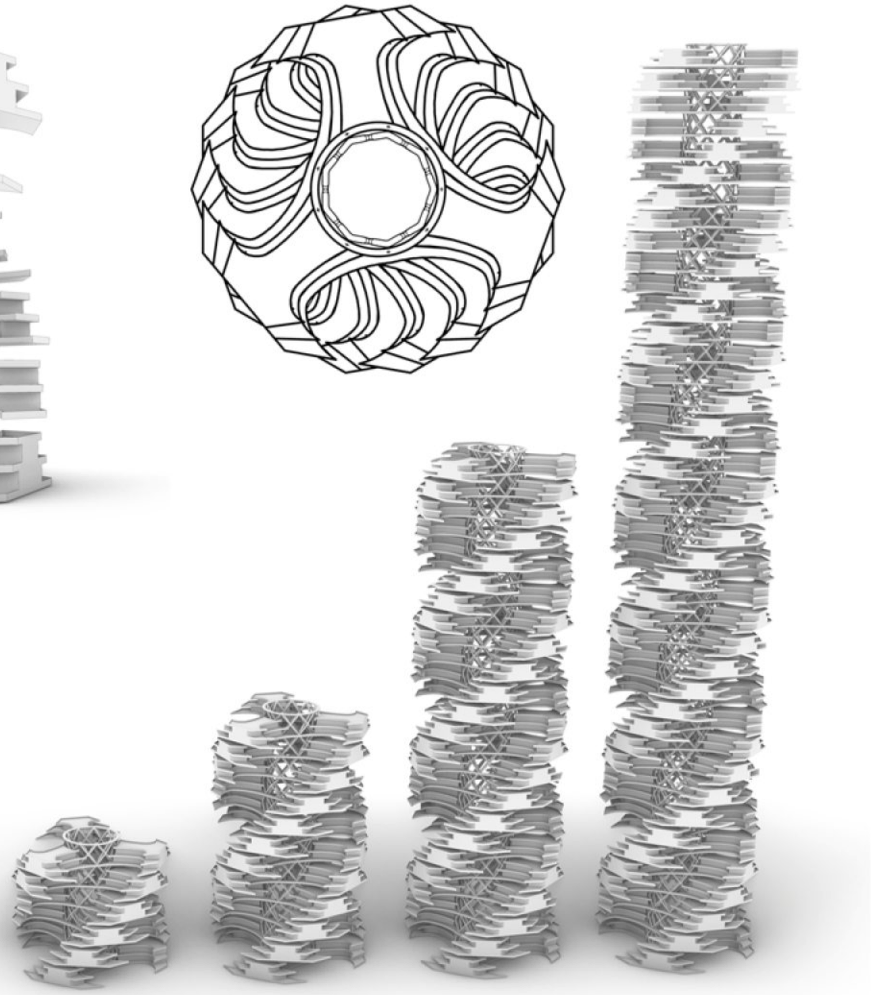
FL_17_open_Wind direction in negative X axle

FL_17_closed_Wind direction in negative X axle

FL_17_closed_Wind direction in X axle

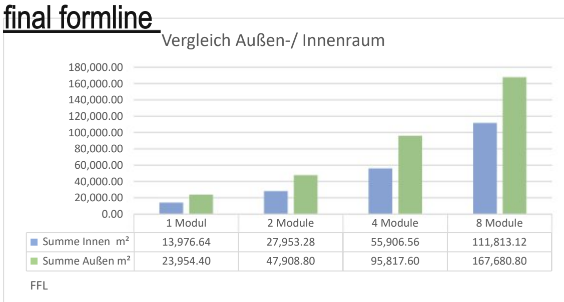
87: Windtunnel Analysis V3





preliminary area comparison - outdoor and indoor spaces

final formline

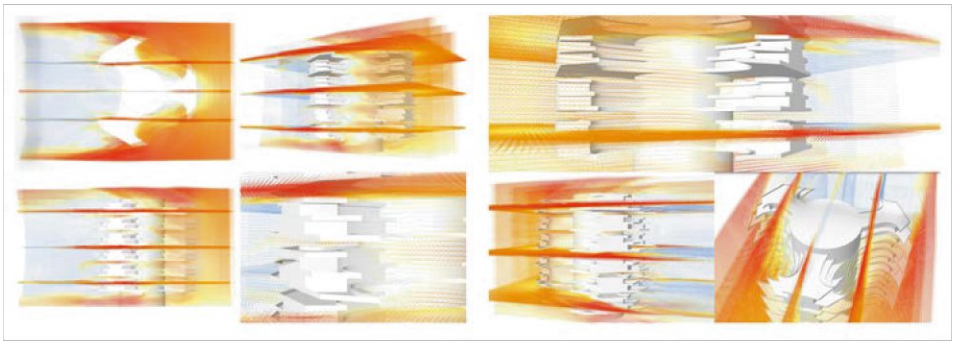


88: Volumes and Area V4

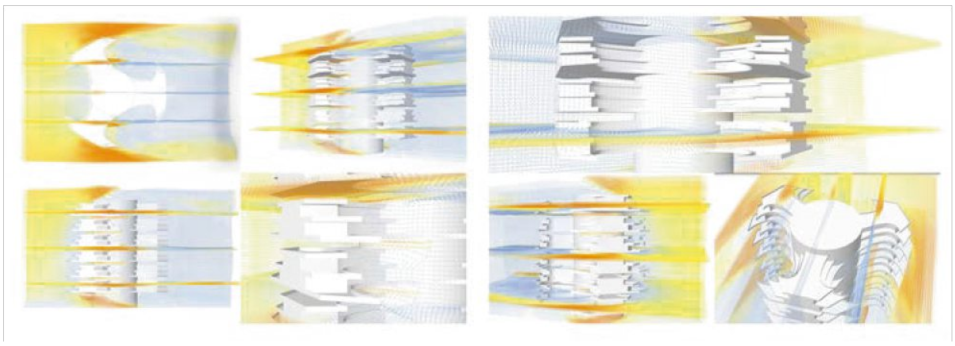
Windtunel - final formline

final_open_Wind direction in negative X axle

final_closed_Wind direction in negative X axle

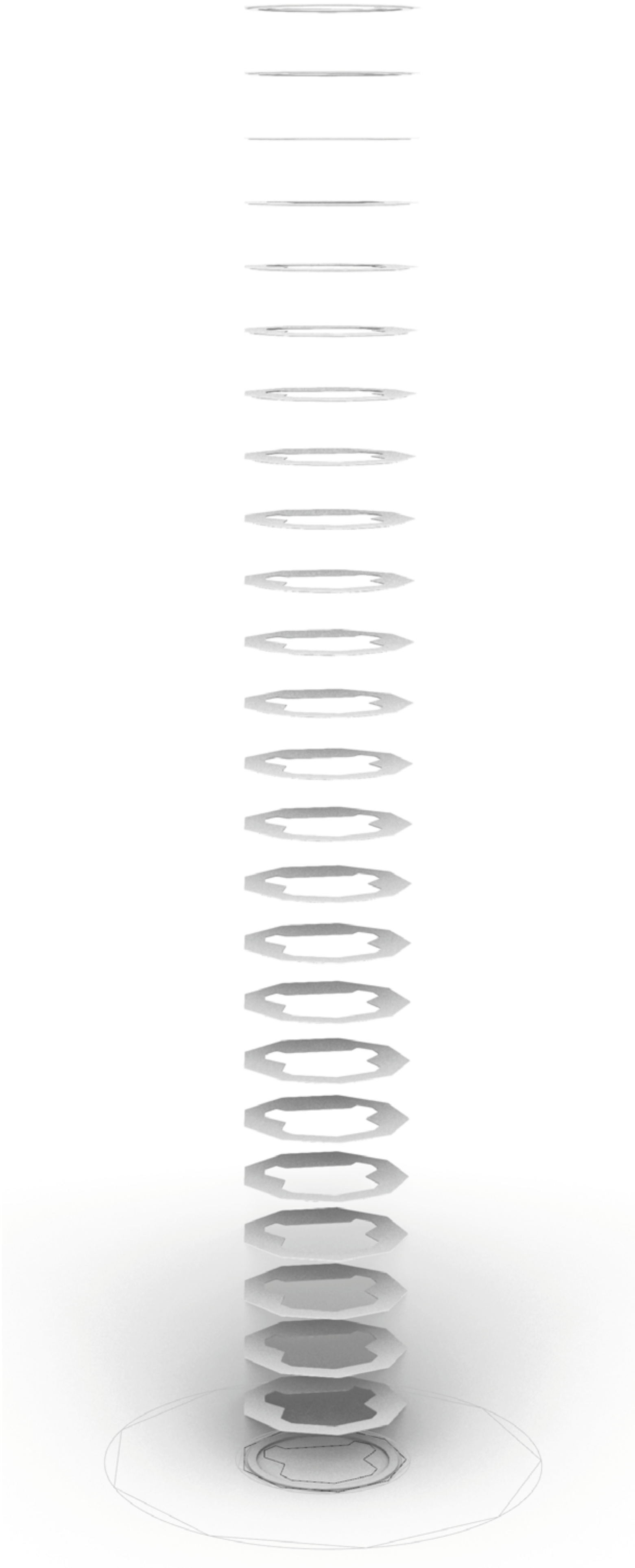


final_closed_Wind direction in X axle

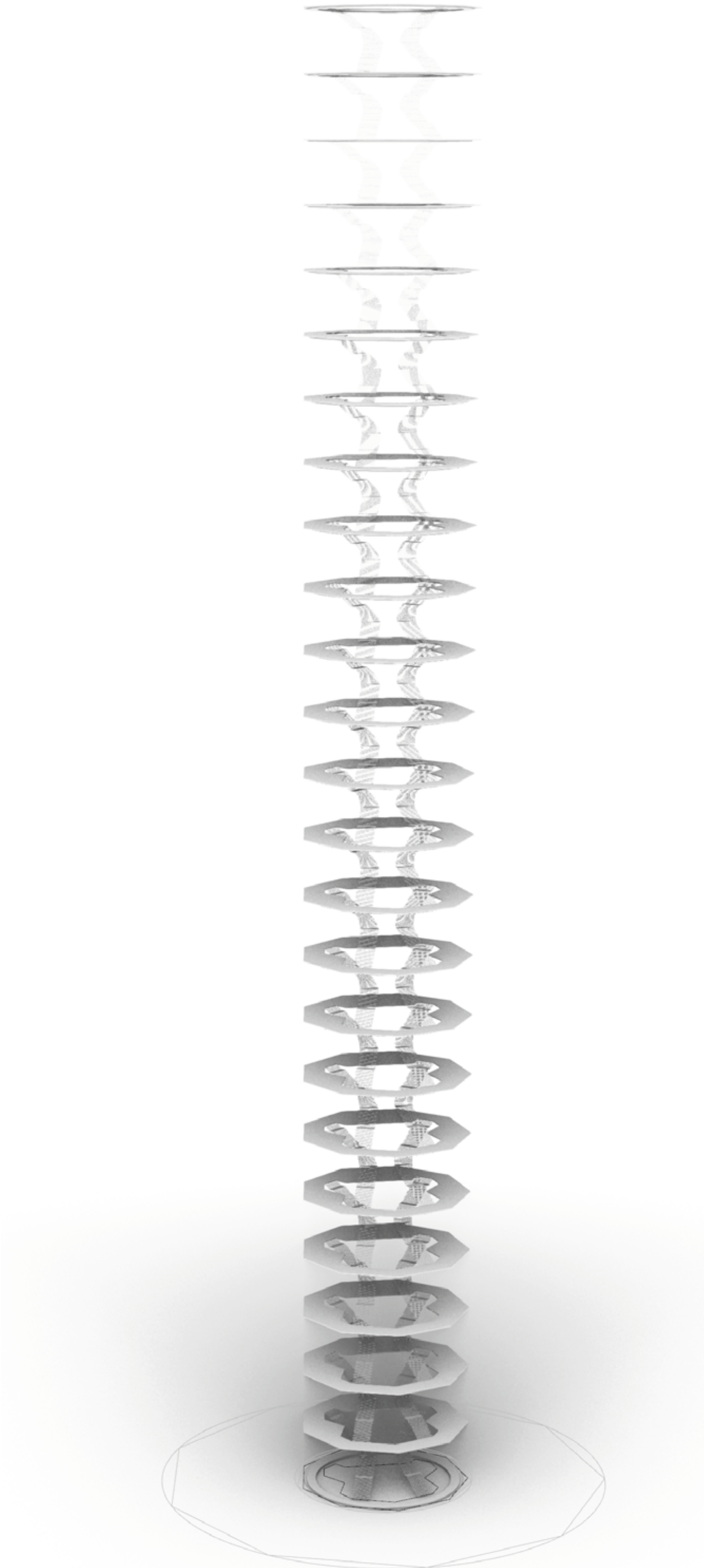


89: Windtunnel Analysis V4

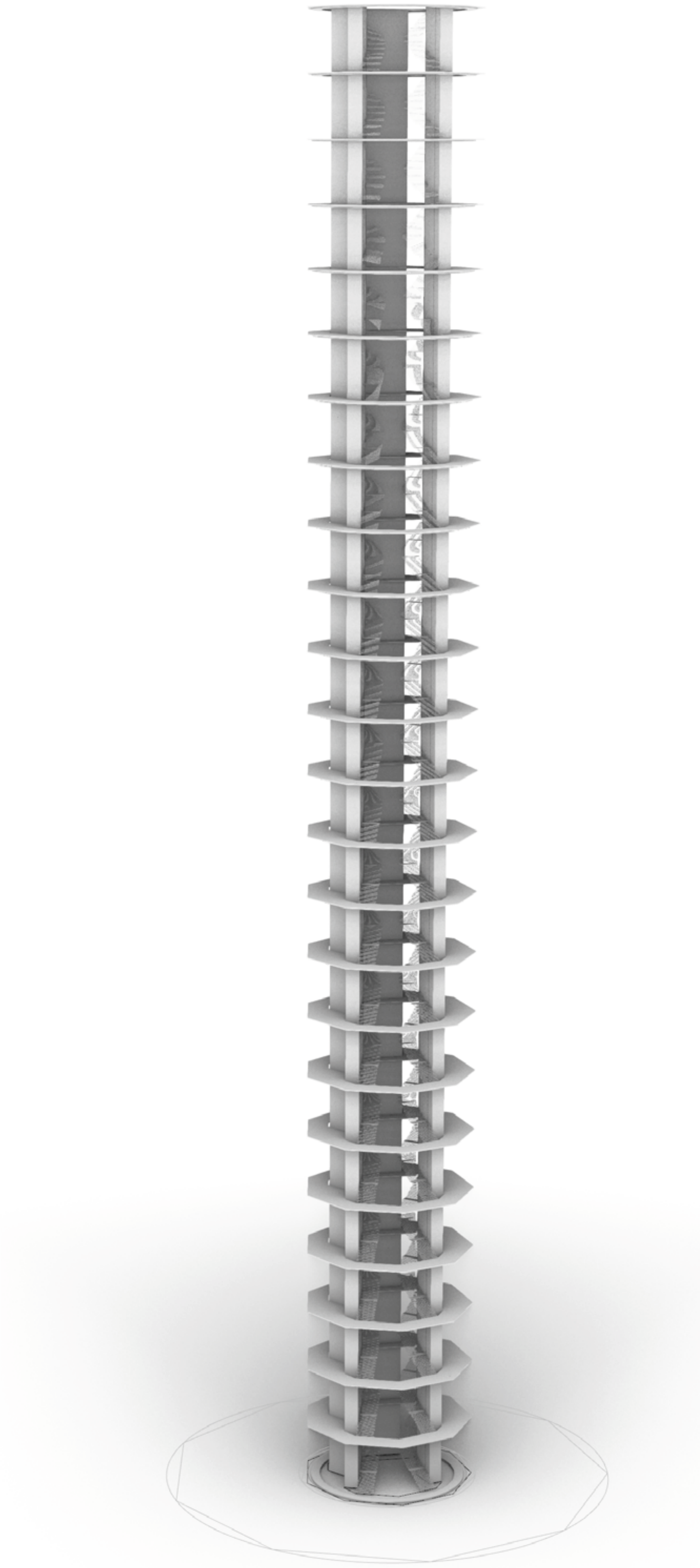
4.4 Structural Schematics



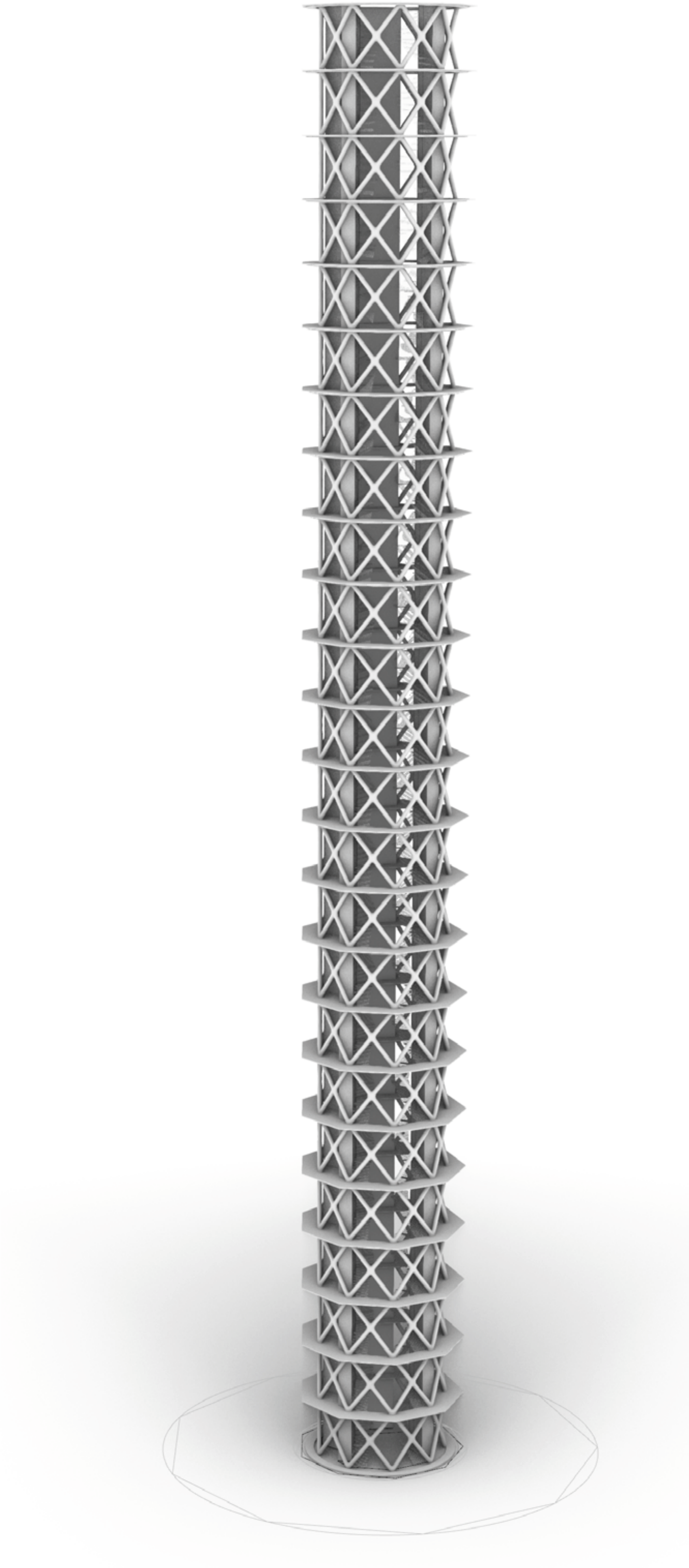
90: Floorplates Core



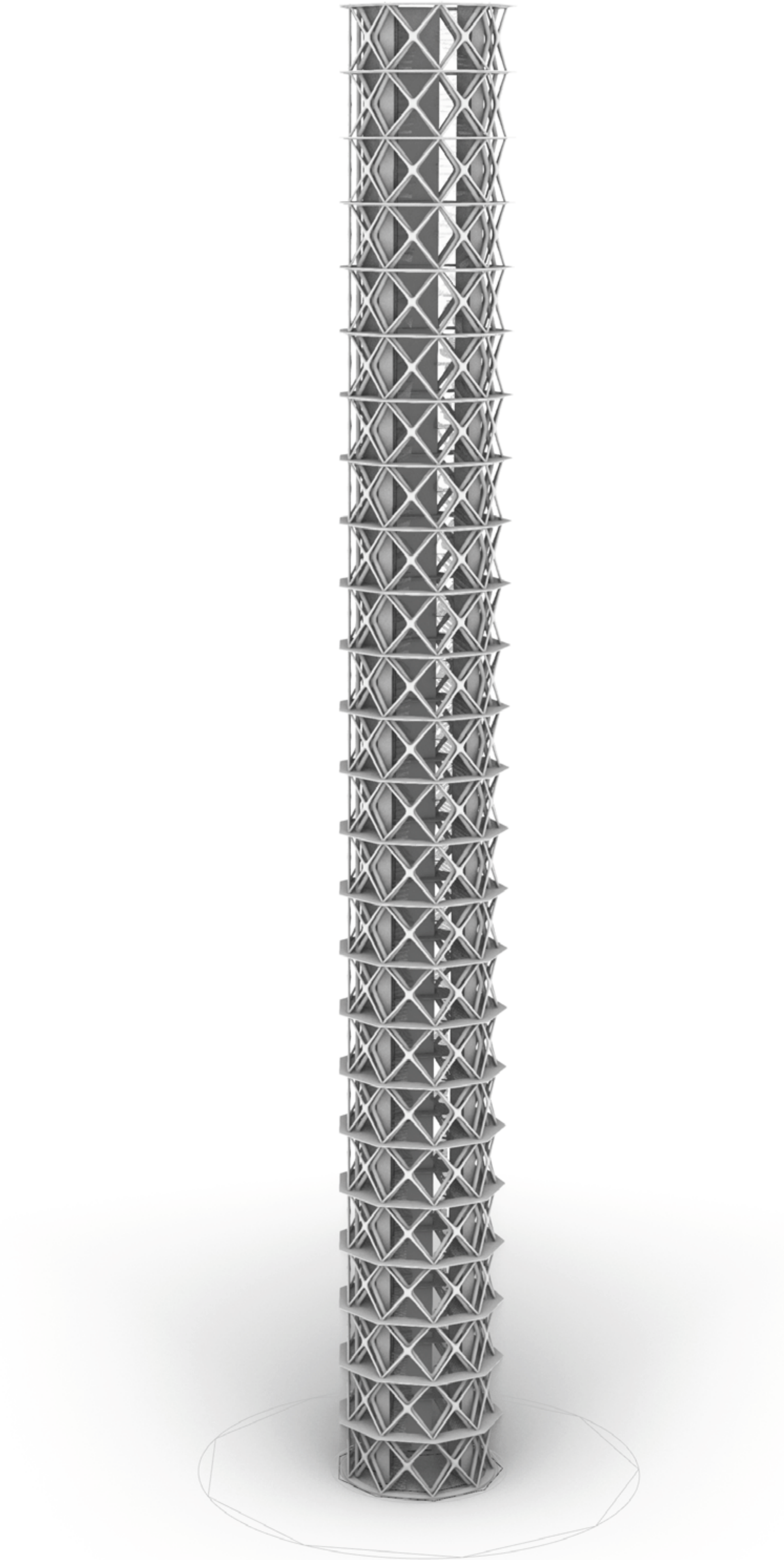
91: Staircase (2 Wings)



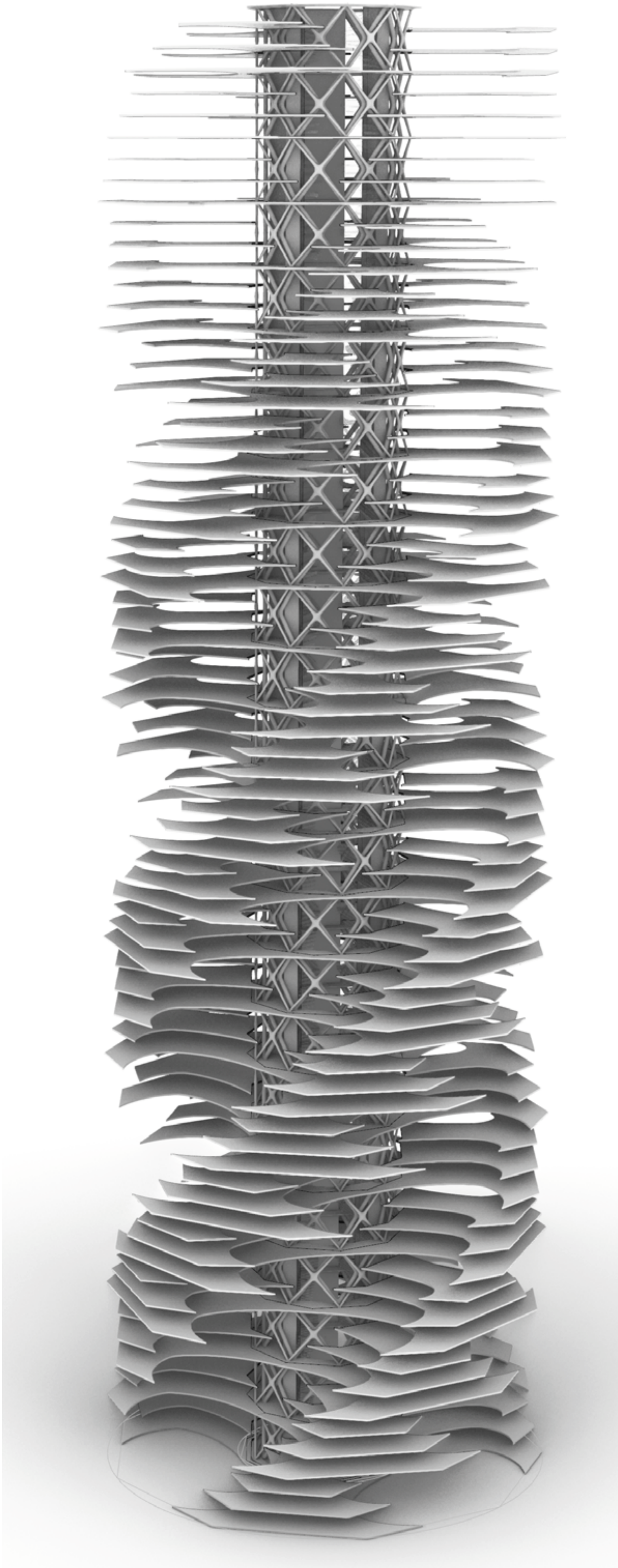
92: Elevator Cores



93: **Preliminary Construction Inner Core**

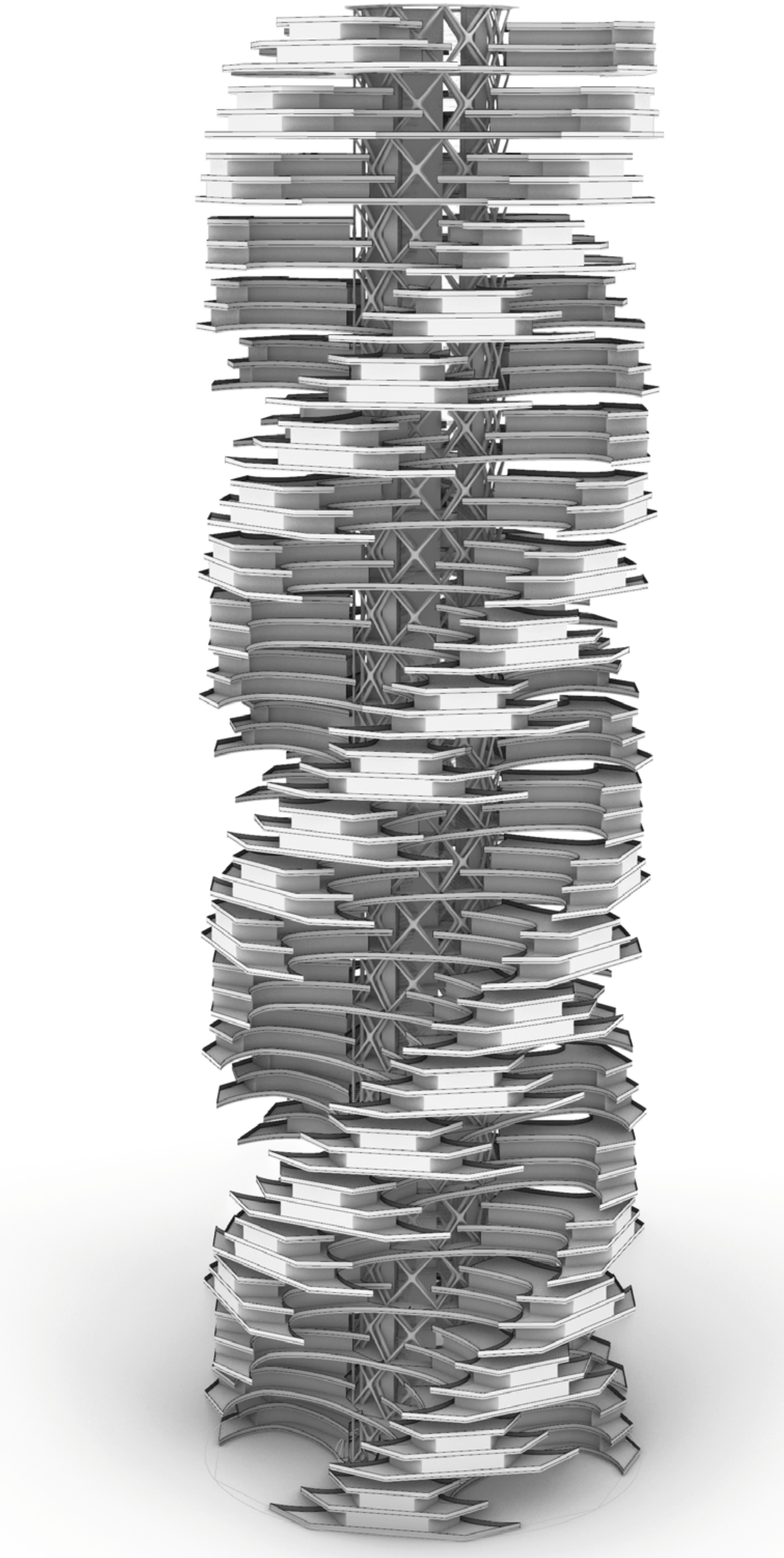


94: Preliminary Construction Core
Elements of Rotational Modules

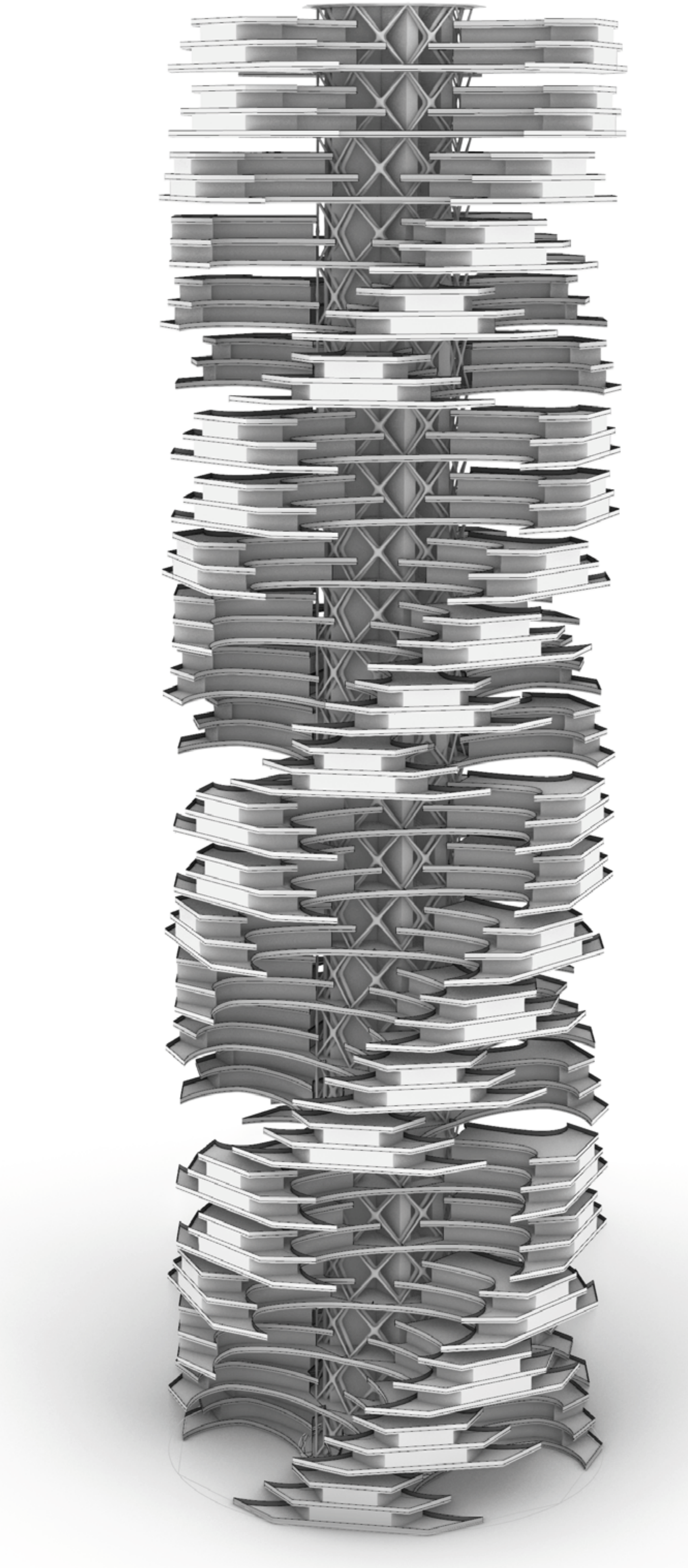


95: Floorplates for Modules

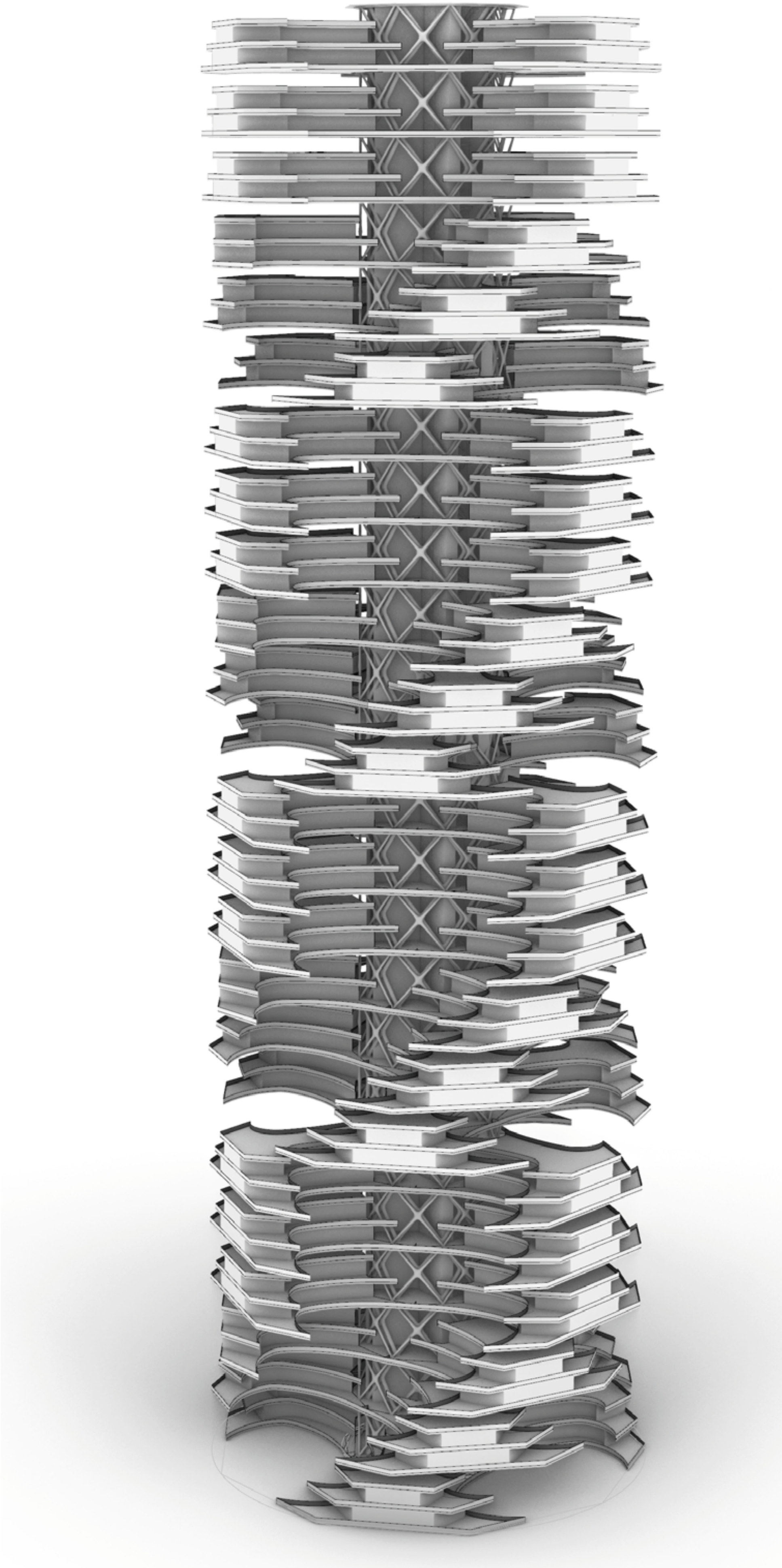
96: Secondary Volumetric Study



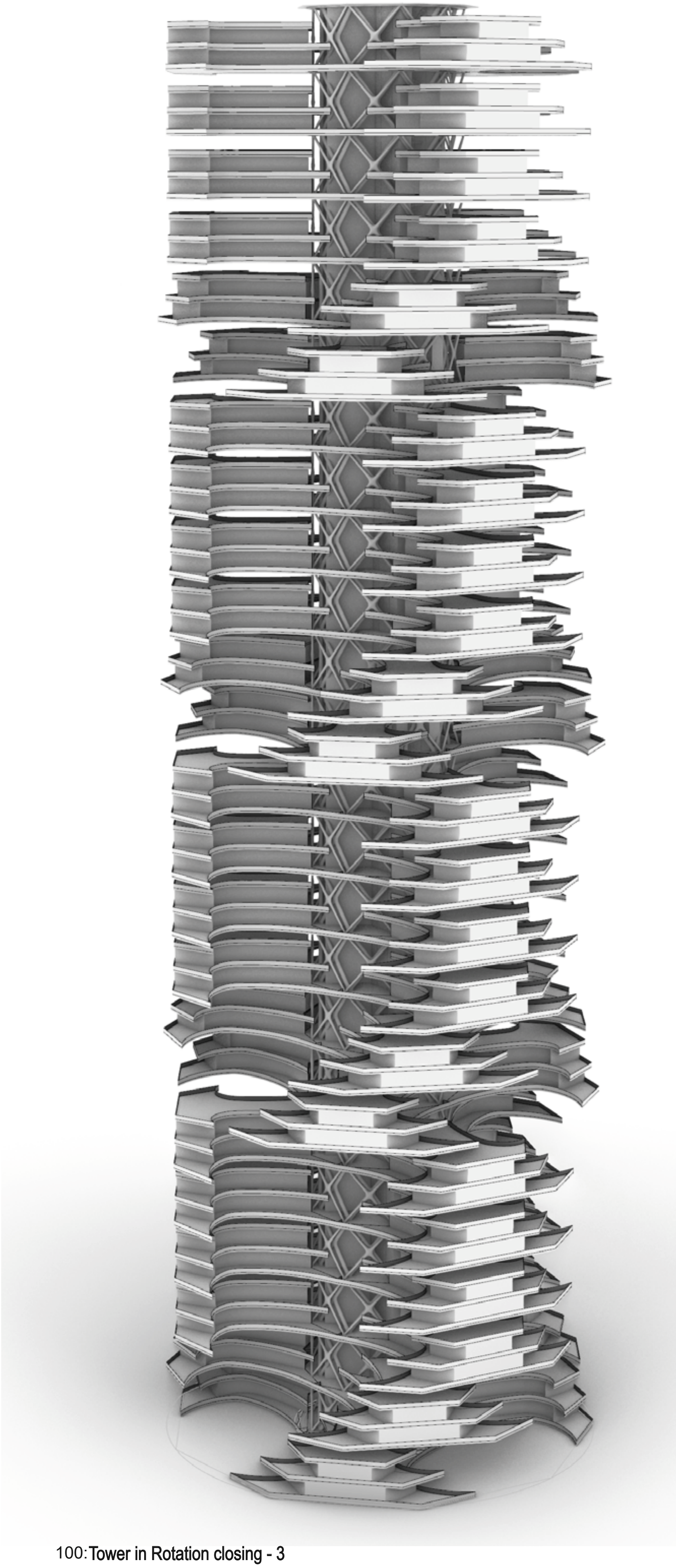
97: Railings



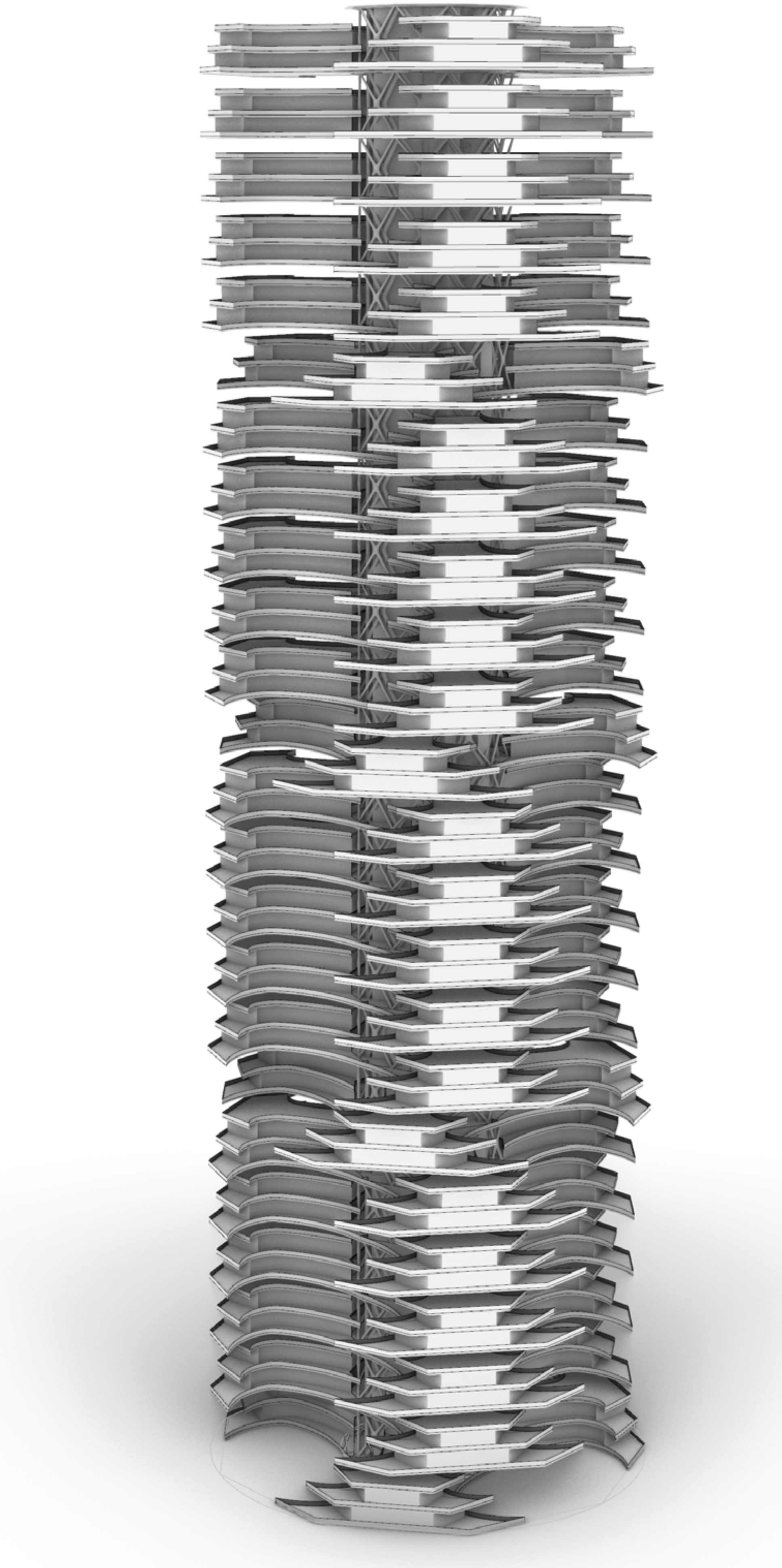
98: Tower in Rotation Closing - 1



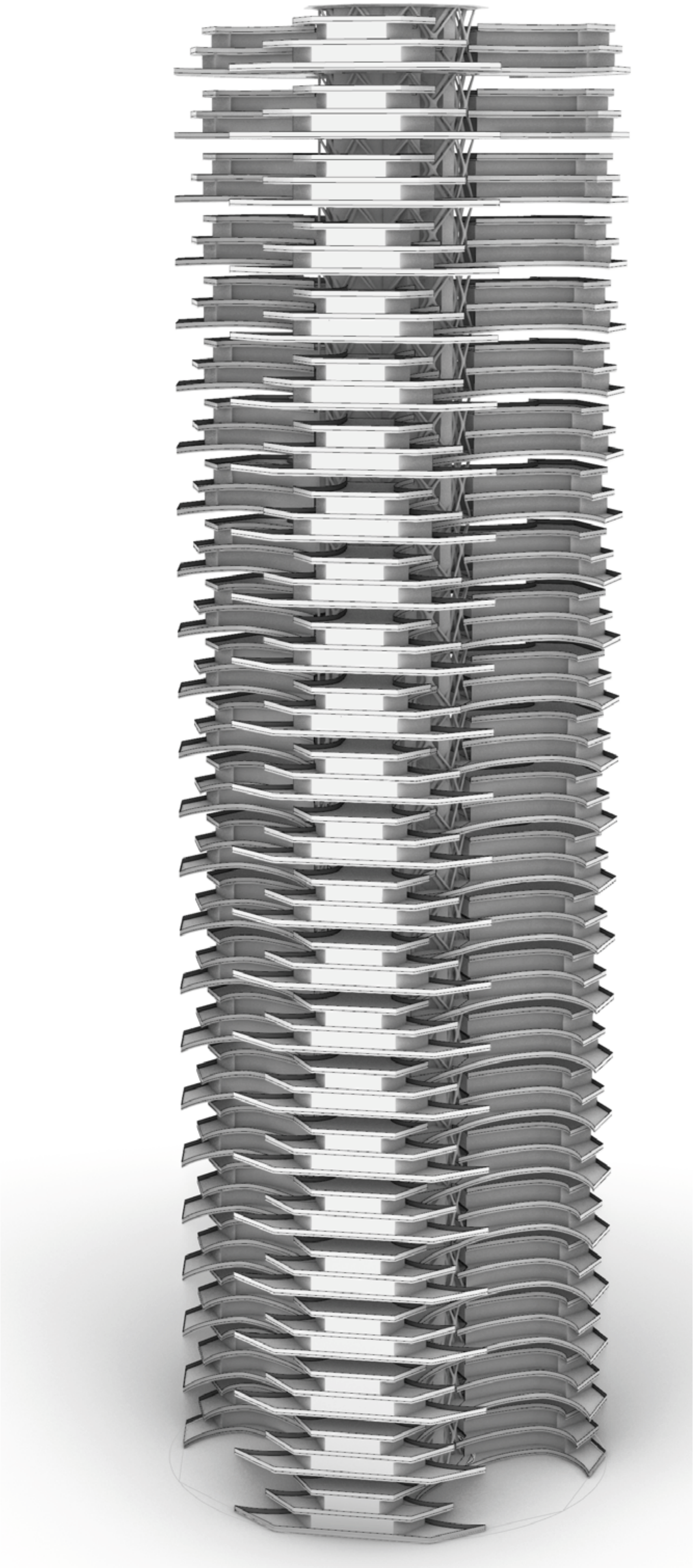
99: Tower in Rotation closing - 2



100:Tower in Rotation closing - 3



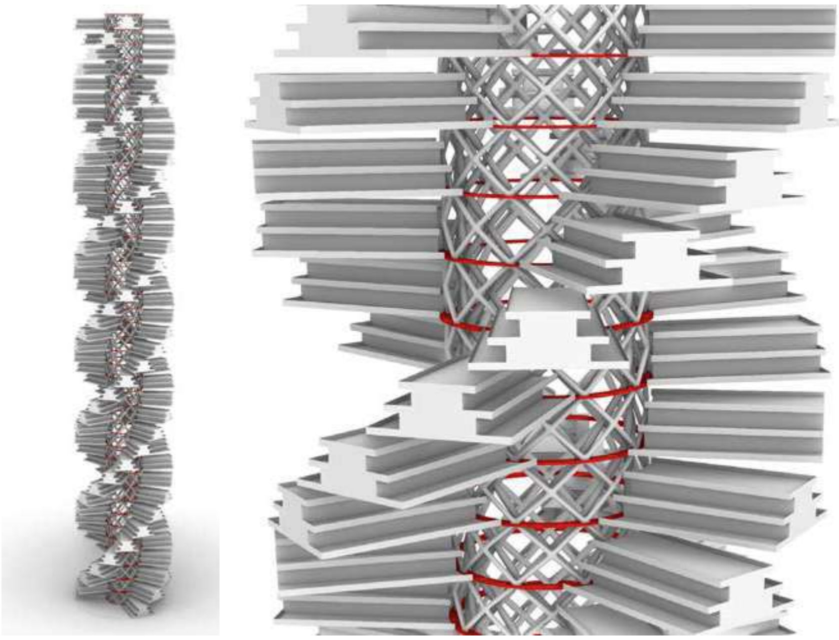
101:Tower in Rotation closing - 4



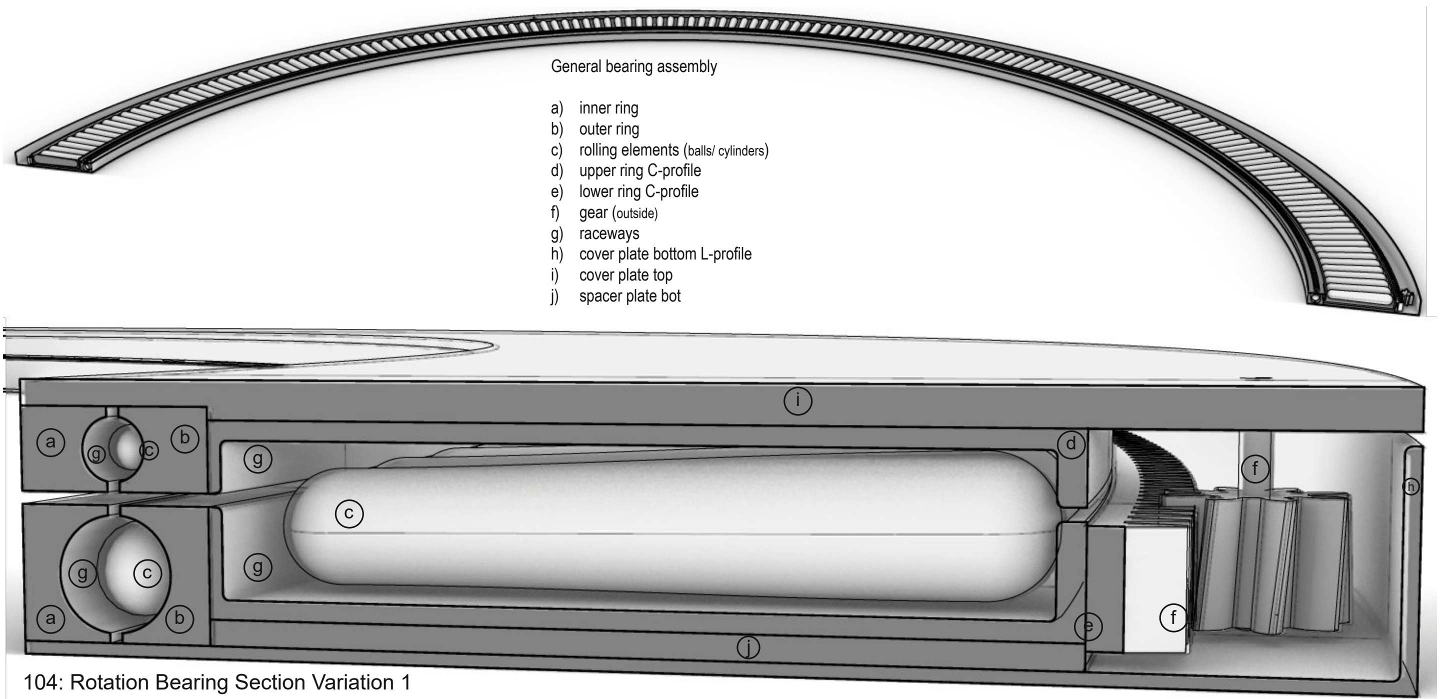
102: Tower in Rotation closing - 5

4.5 Rotational Bearing on Console

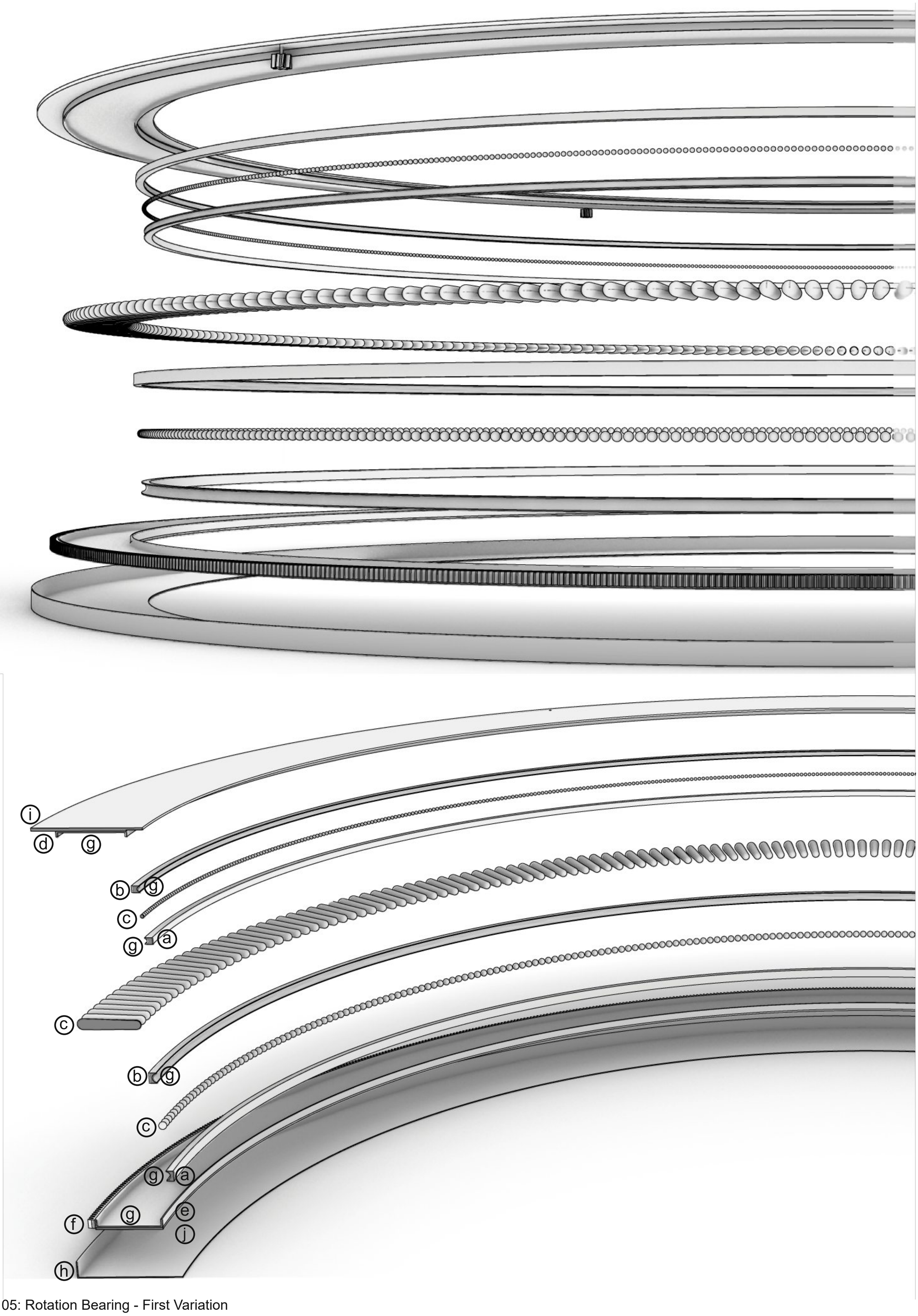
In order to construct the rotating tower I envisioned I soon started to dive into studies of different rotational slewing bearings as explained above. After the initial studies I started to think and develope my own rotational bearing considering the given constraints and limitations. During this and the other constructive phases and elaborations of this project I was supported by Mr. Karl Deix and Mr Christoph Müller who supported the project regarding the structural engineering aspects and considerations. Again all the variations that have been tested drawn and discarded during the course of this work would exceed the scope of this work. Therefore below I will only shortly depict the most relevant variations: First was a very slender approach that was based on the idea of the rotational modules resting directly ontop of each other therefore not requiring any additional console in order to anchor back to the inner main core where the shafts and circulatory need of the building are beeing met.



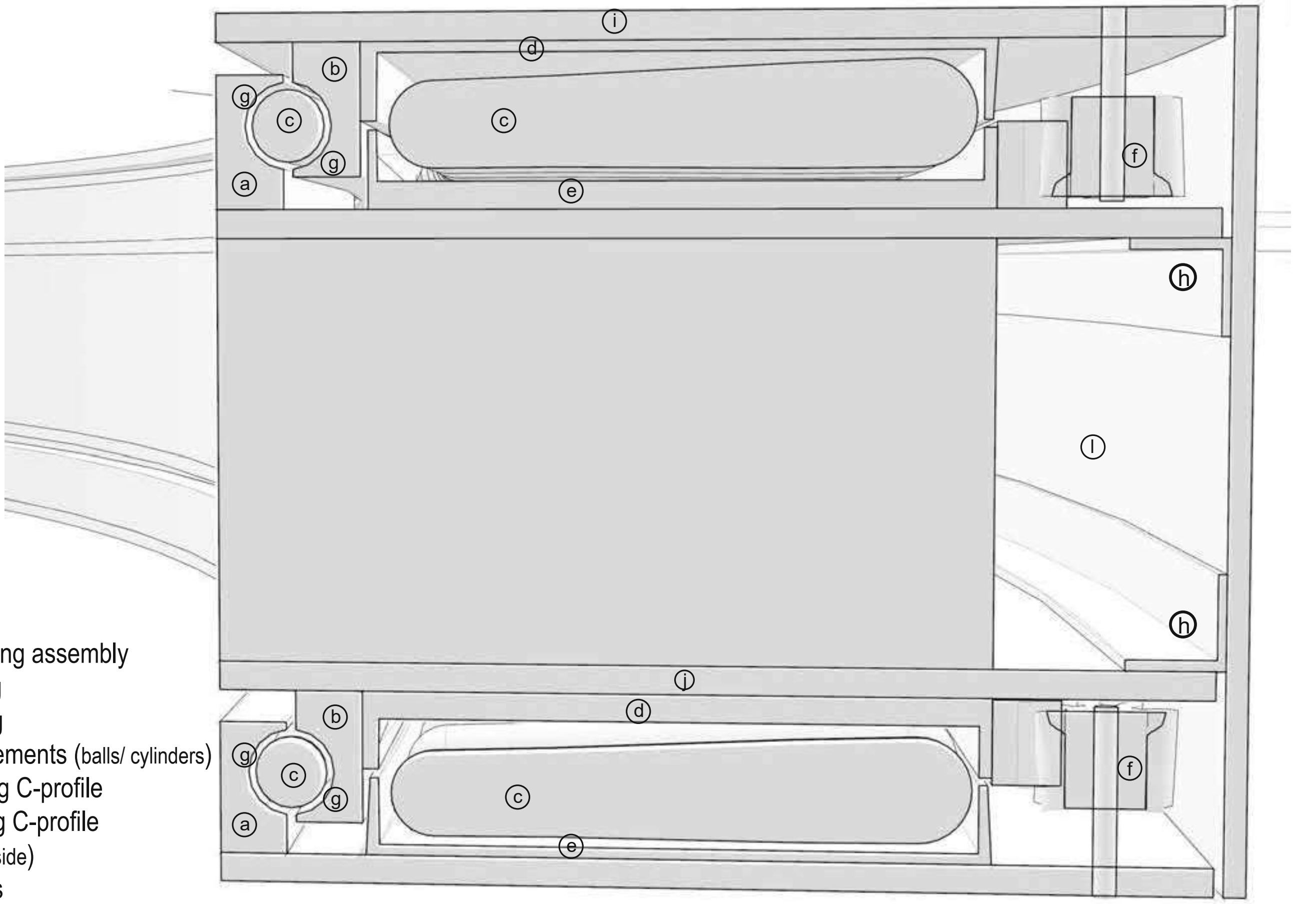
103: Rotation Bearing Locations



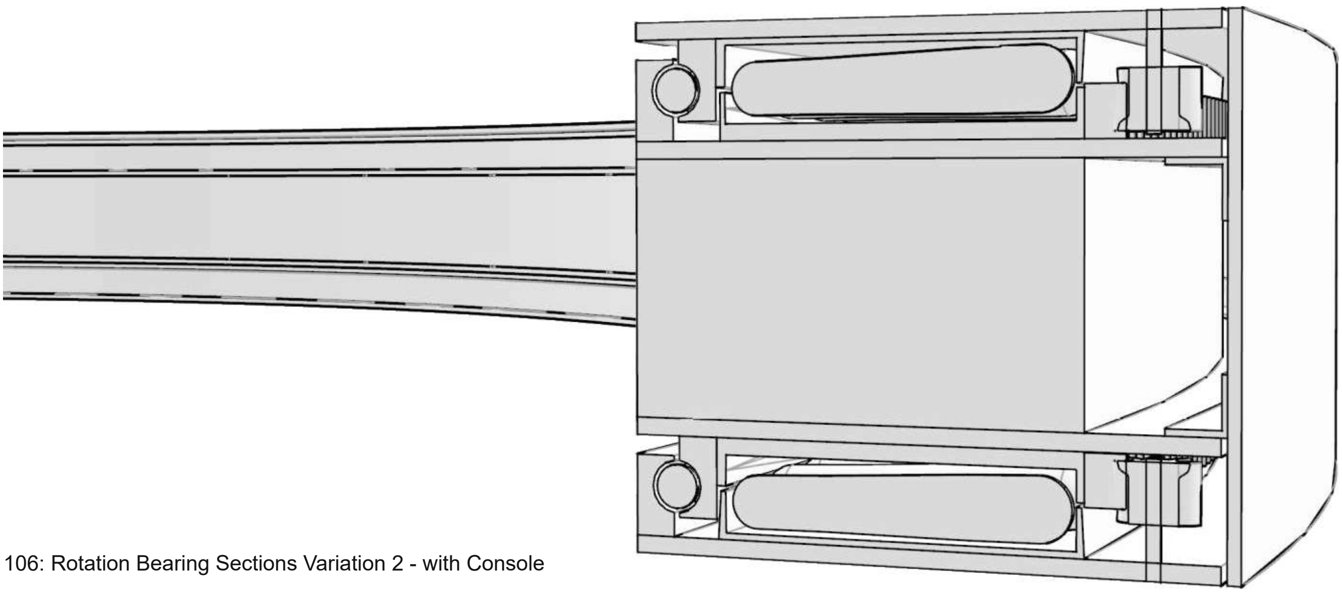
104: Rotation Bearing Section Variation 1



105: Rotation Bearing - First Variation
Parts - Exploded



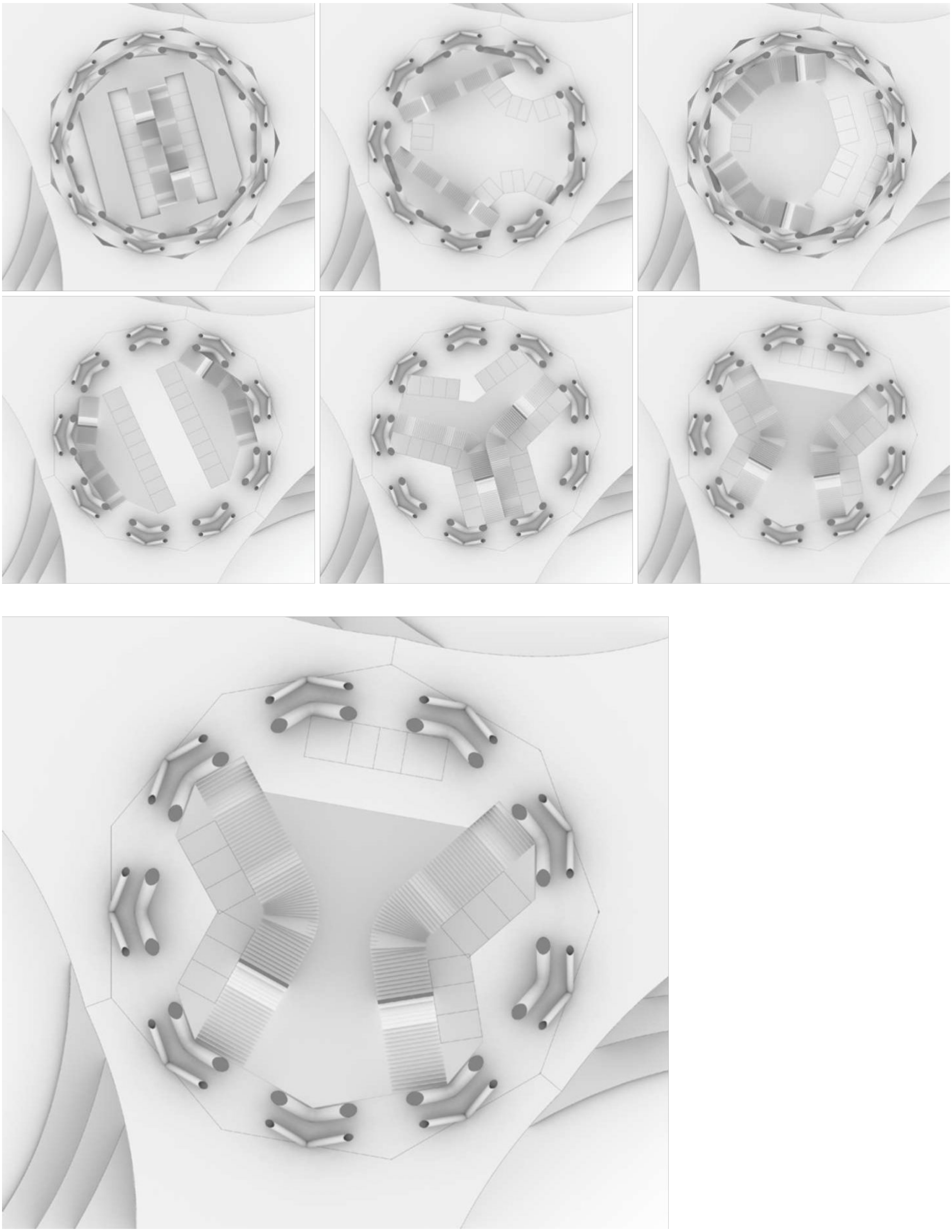
General bearing assembly
a) inner ring
b) outer ring
c) rolling elements (balls/ cylinders)
d) upper ring C-profile
e) lower ring C-profile
f) gear (outside)
g) raceways
h) duct cover plate L-profile
i) cover plate top
j) spacer plate
k) console
l) utility space ac plumbing etc.



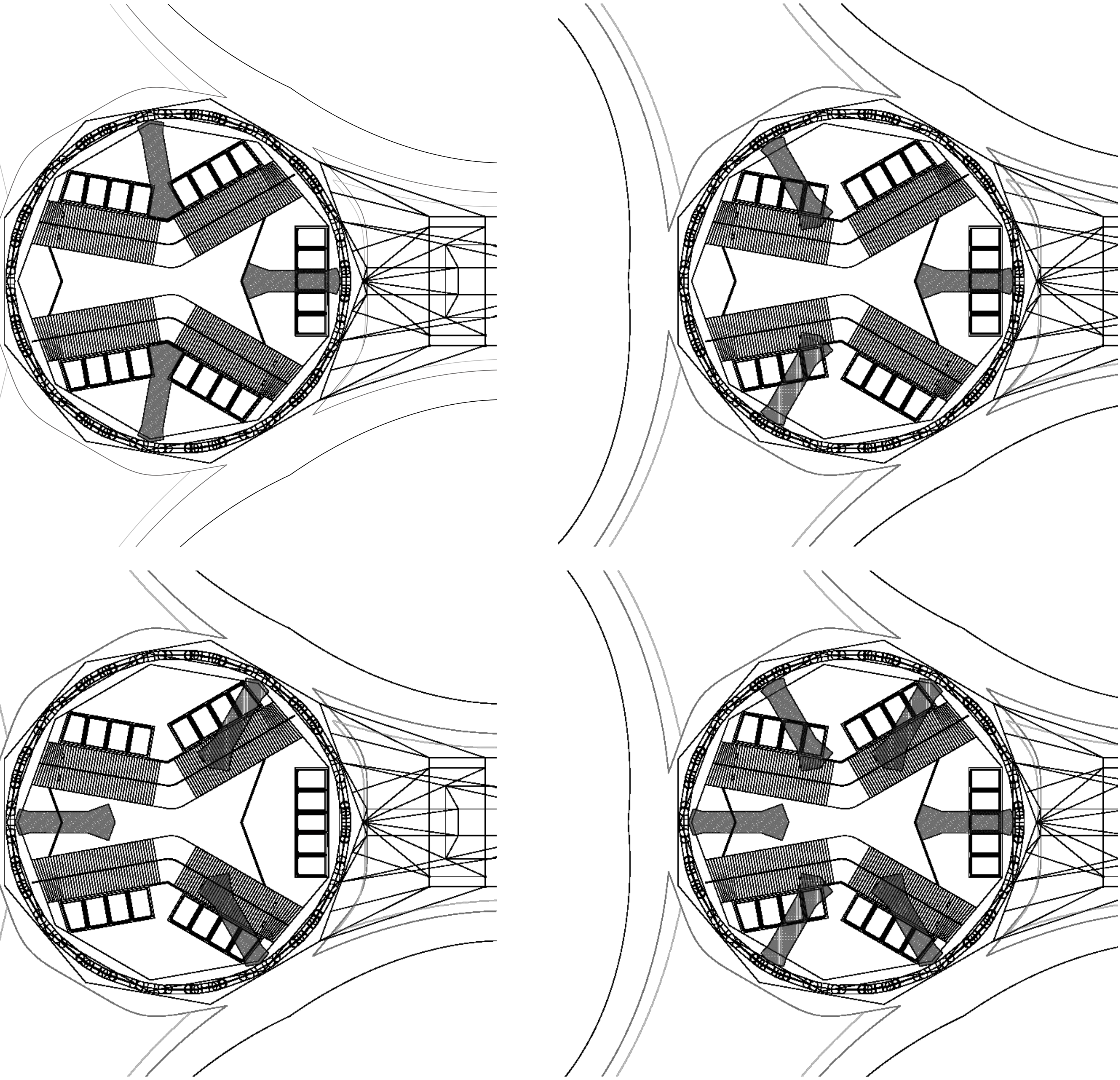
106: Rotation Bearing Sections Variation 2 - with Console

4.6 Circulation Development

selected circulation variations



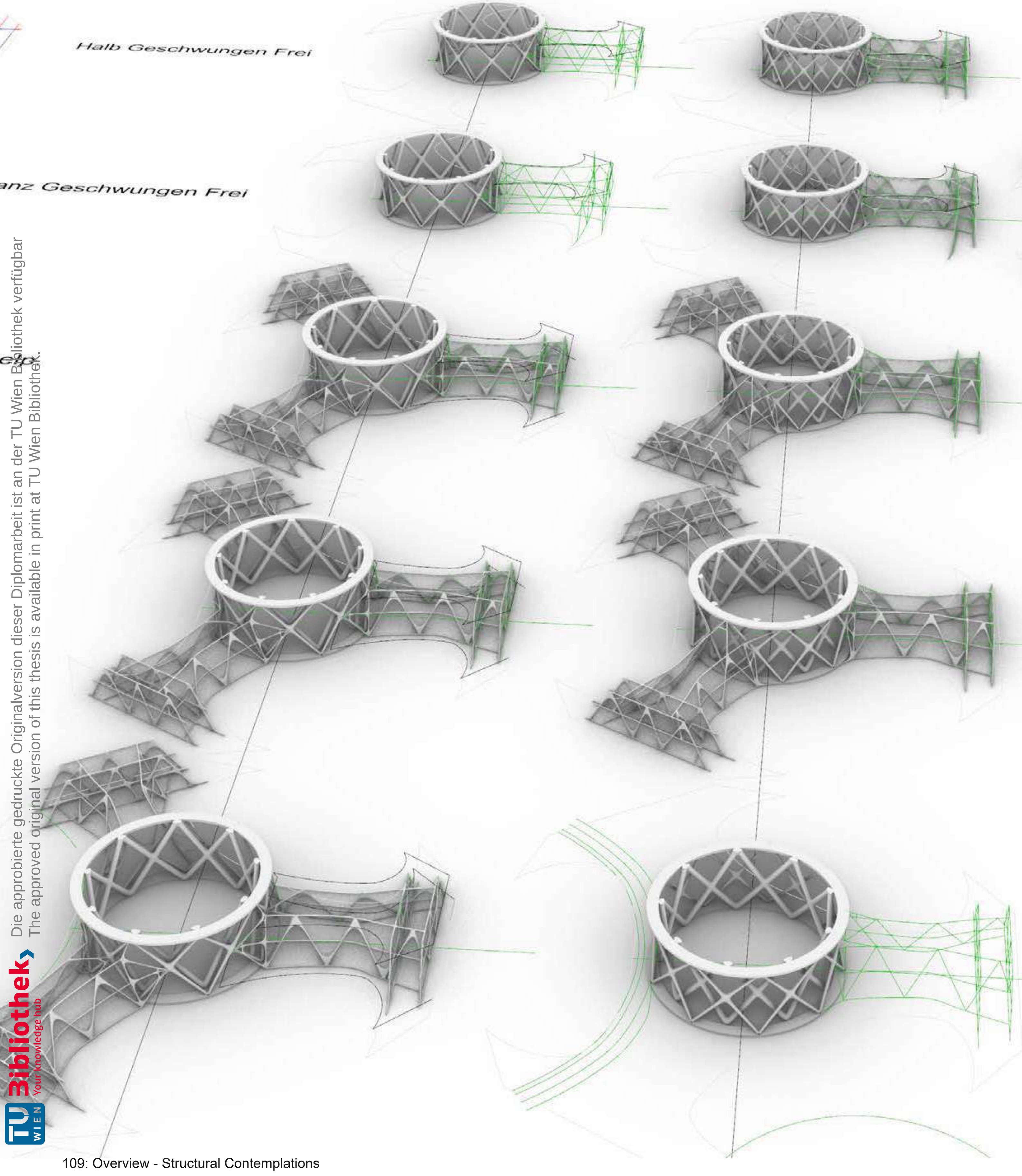
107: Staircase and Elevator Arrangements



108: Sketches of Concrete Collum considerations

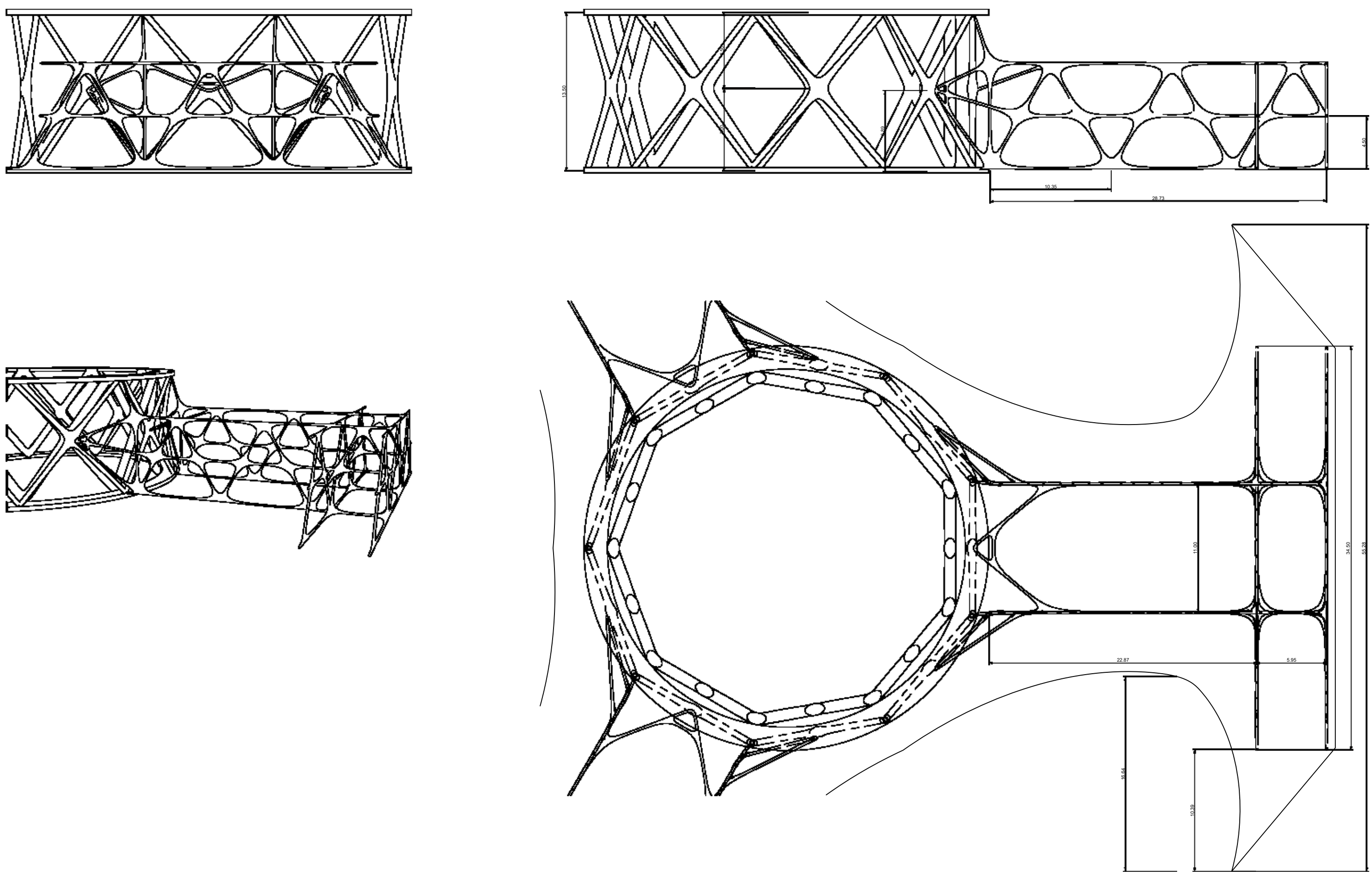
Consideration if elevator cores are sufficient to provide stiffnes for the entire towers design of if additional concret swords inbetween the elevators or the circulation pathways would have been necessary. After consultation with the structural engineering advisors it was decided that the elevator shafts if slightly rotated on the single core could provide the necessary stiffnes and would not require additional conccrete swords for support. The elevator arrangement was adapted and the free open atrium space in the core of the highrise could be preserved. In order to reach the necessary rigidity inside the core and increase the maximum buckling load that poses the most important limiting constraint in this design proposal the elevator shafts are executed with tapering walls providing the most support in the lower storeys and reducing it's weight significantly upon reaching the further heights of the tower. The final result for the circulation core in the center of the innovative tower will be shown in chapter five - results.

4.7 Initial Structural Explorations

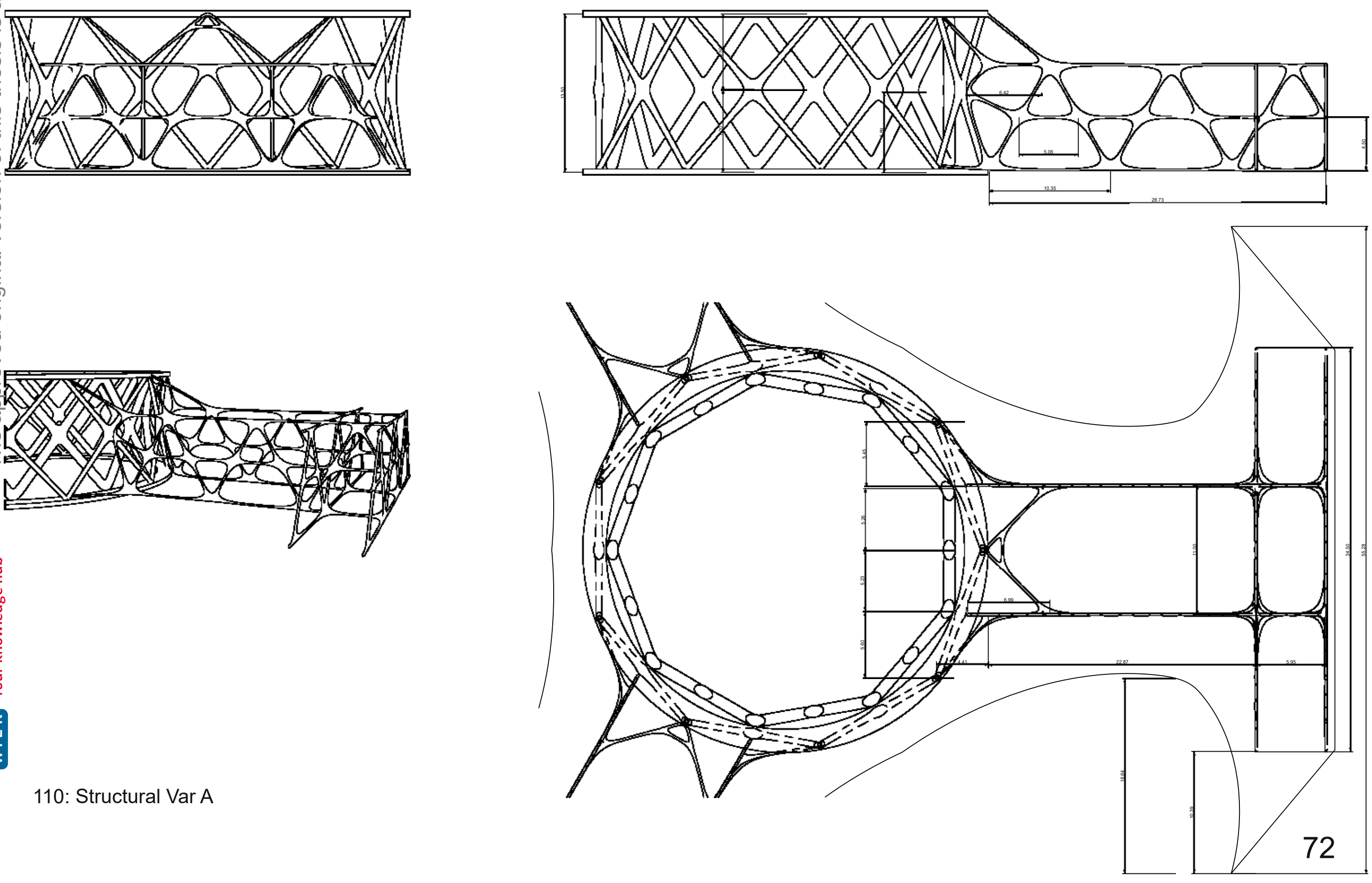


109: Overview - Structural Contemplations

Var A

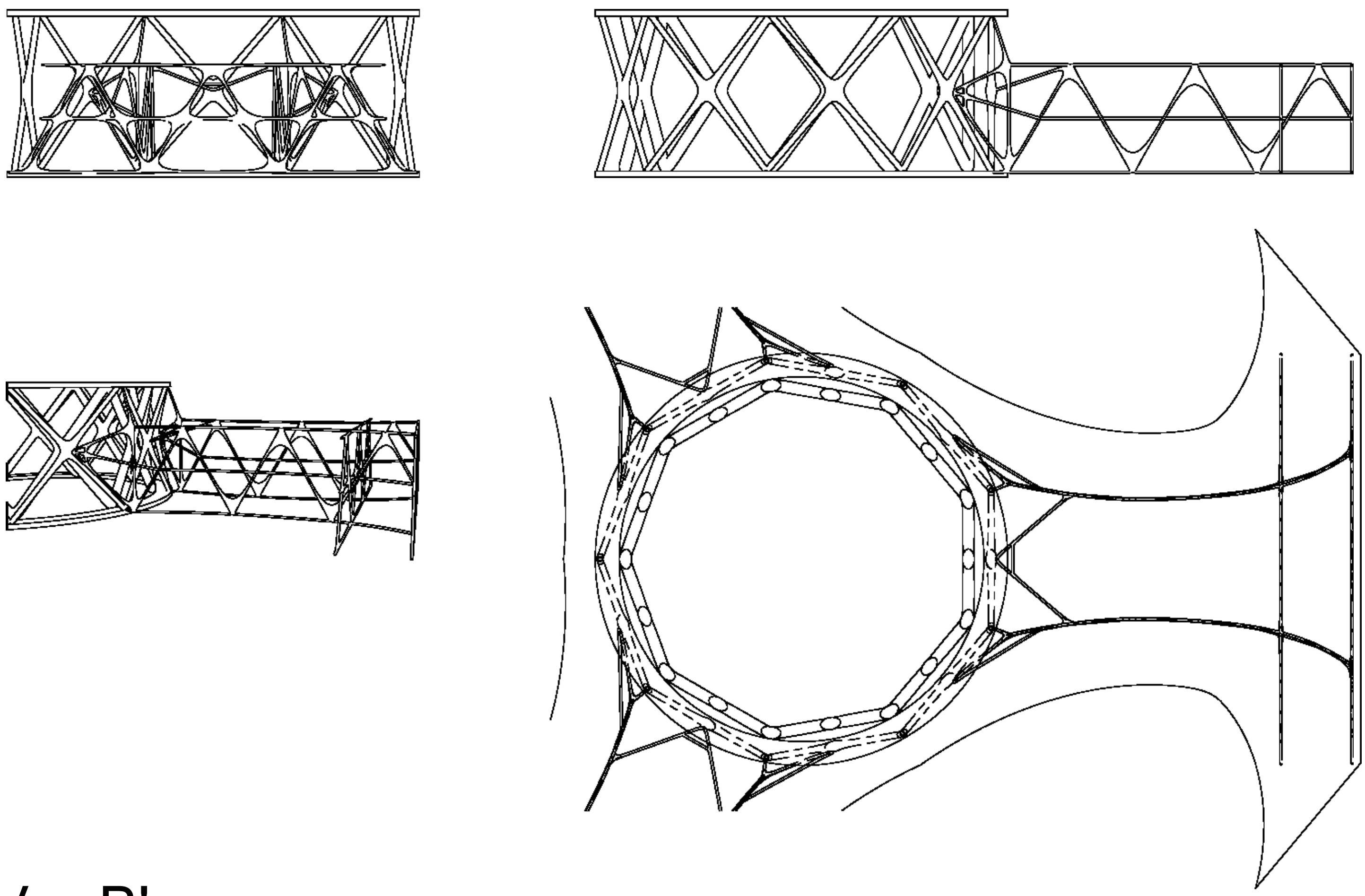


Var A'

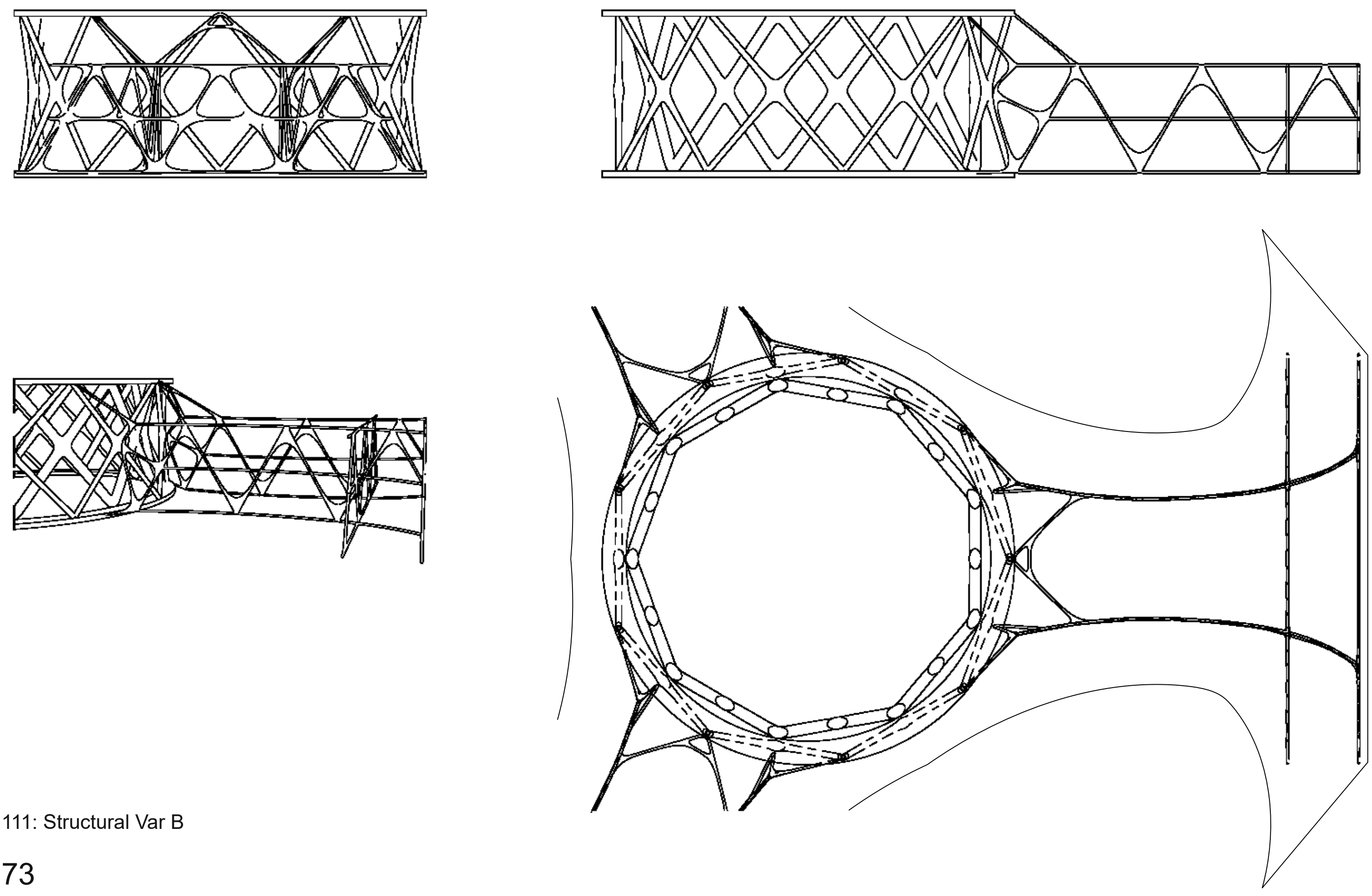


110: Structural Var A

Var B

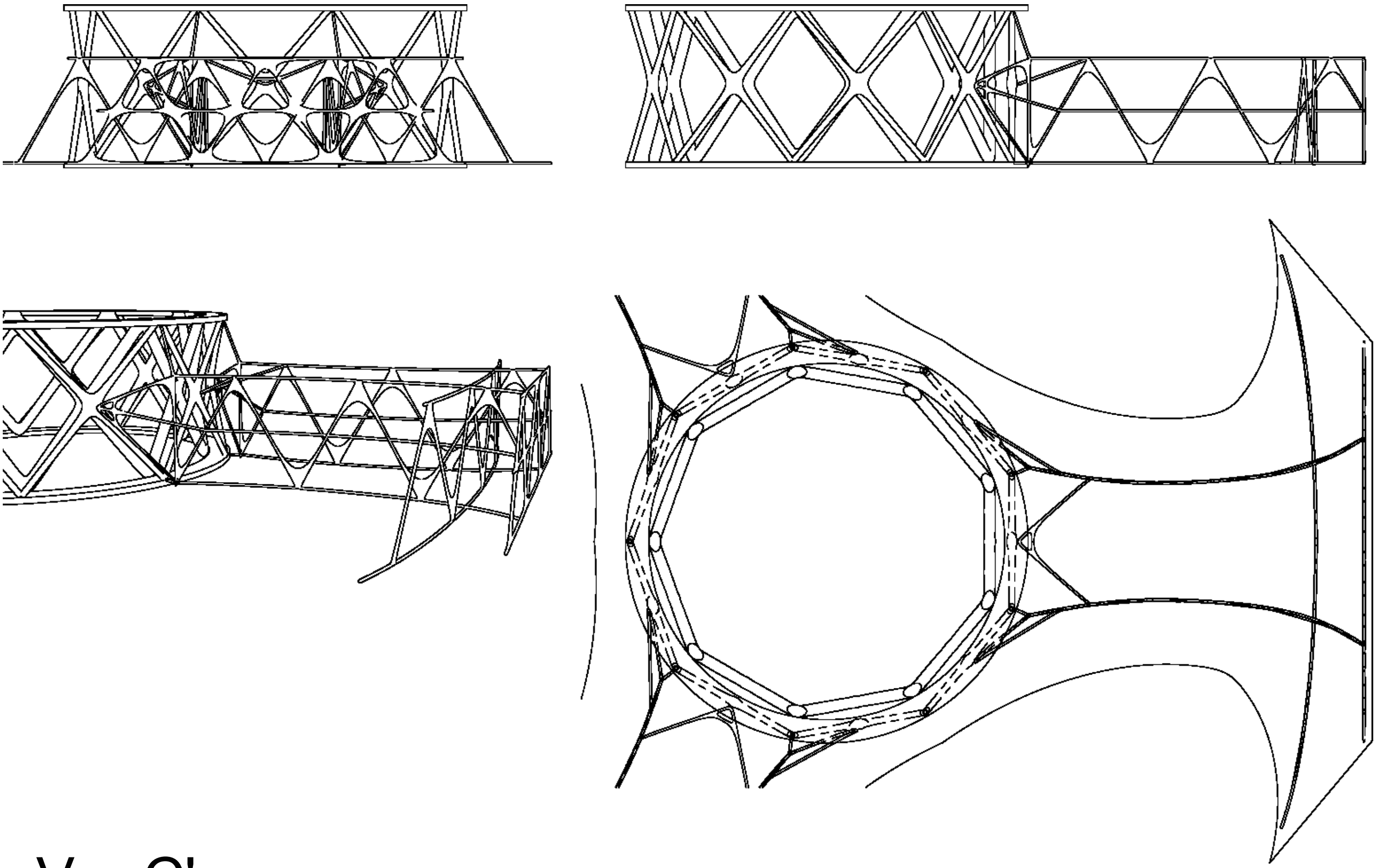


Var B'

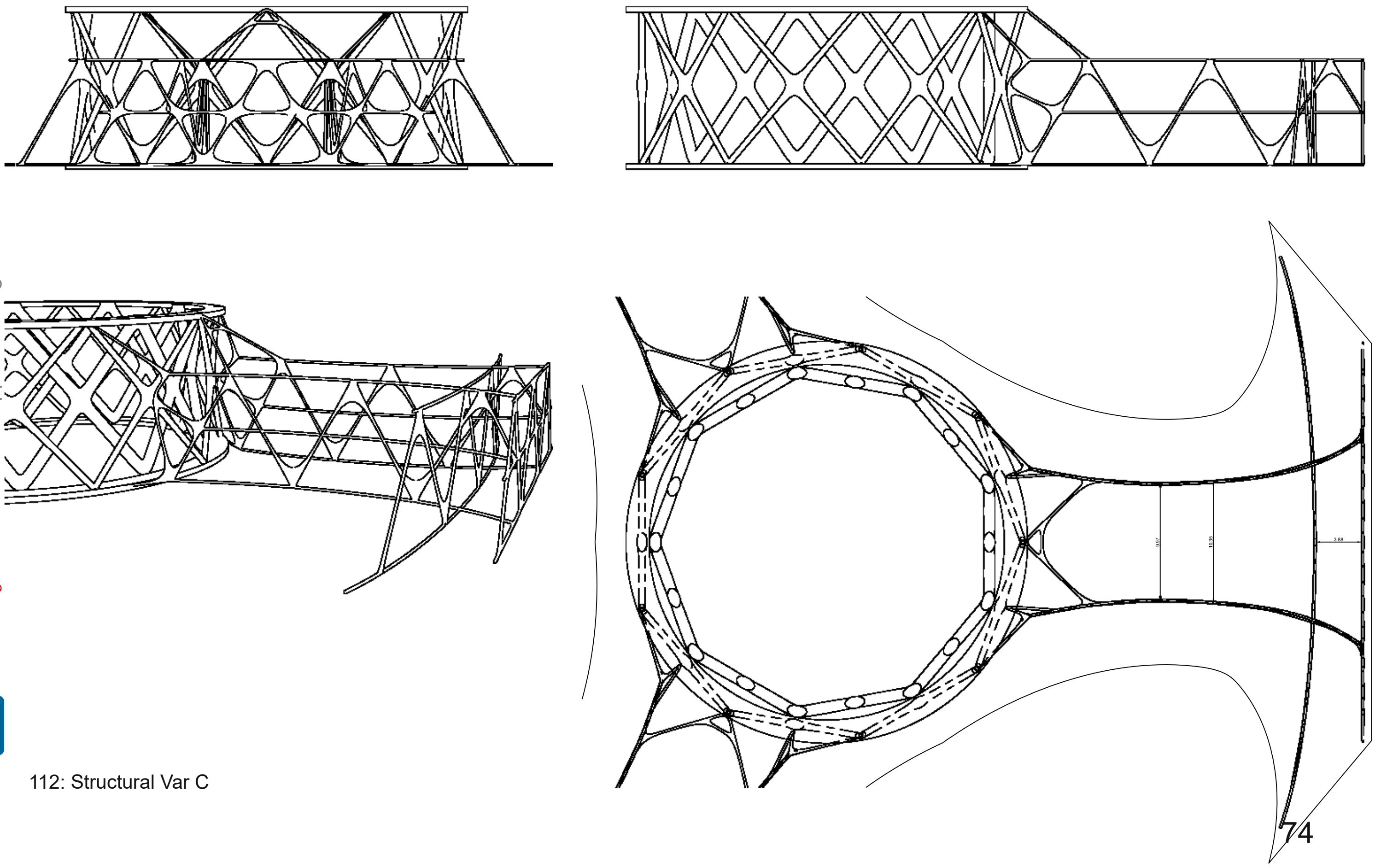


111: Structural Var B

Var C

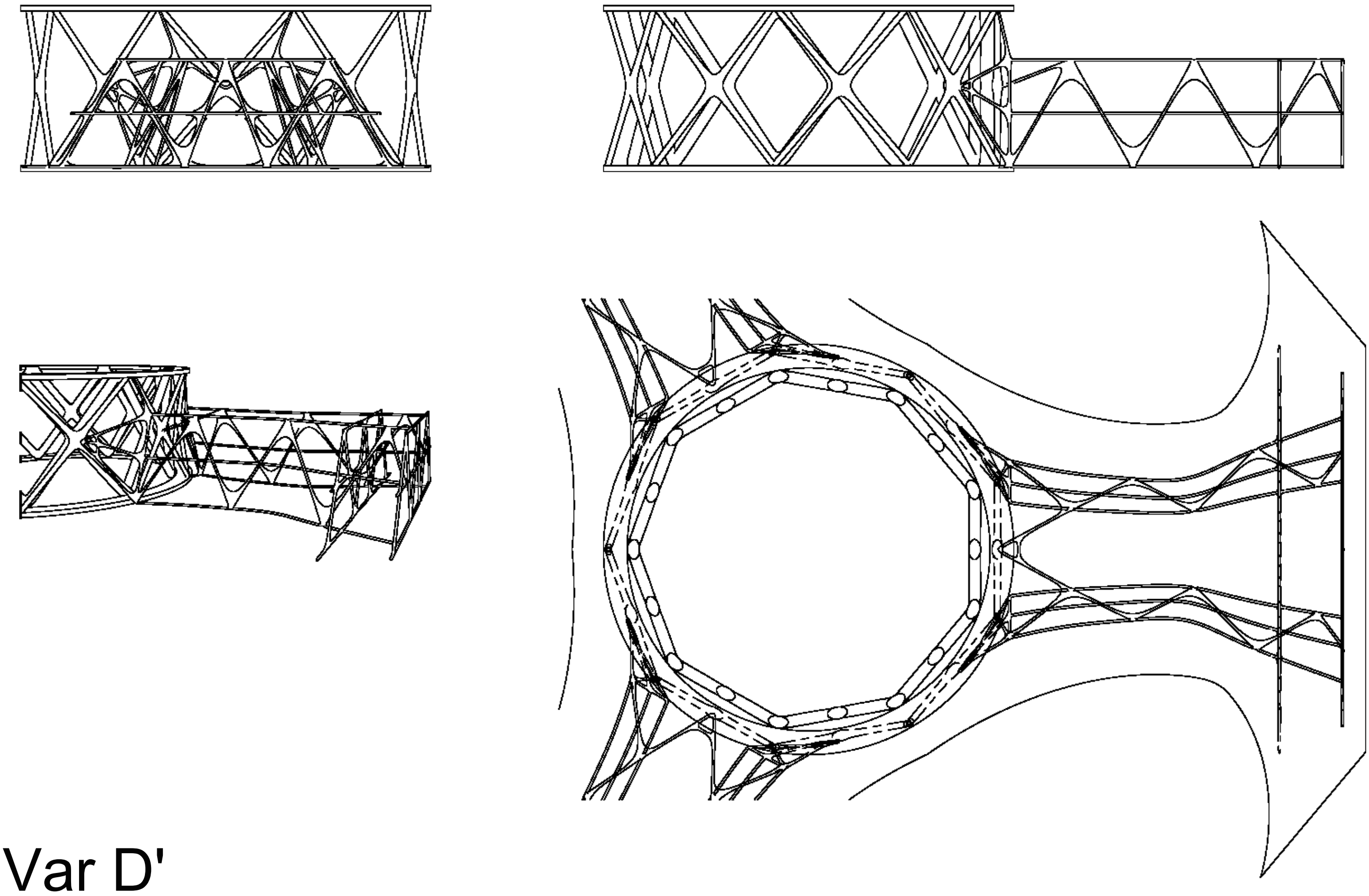


Var C'

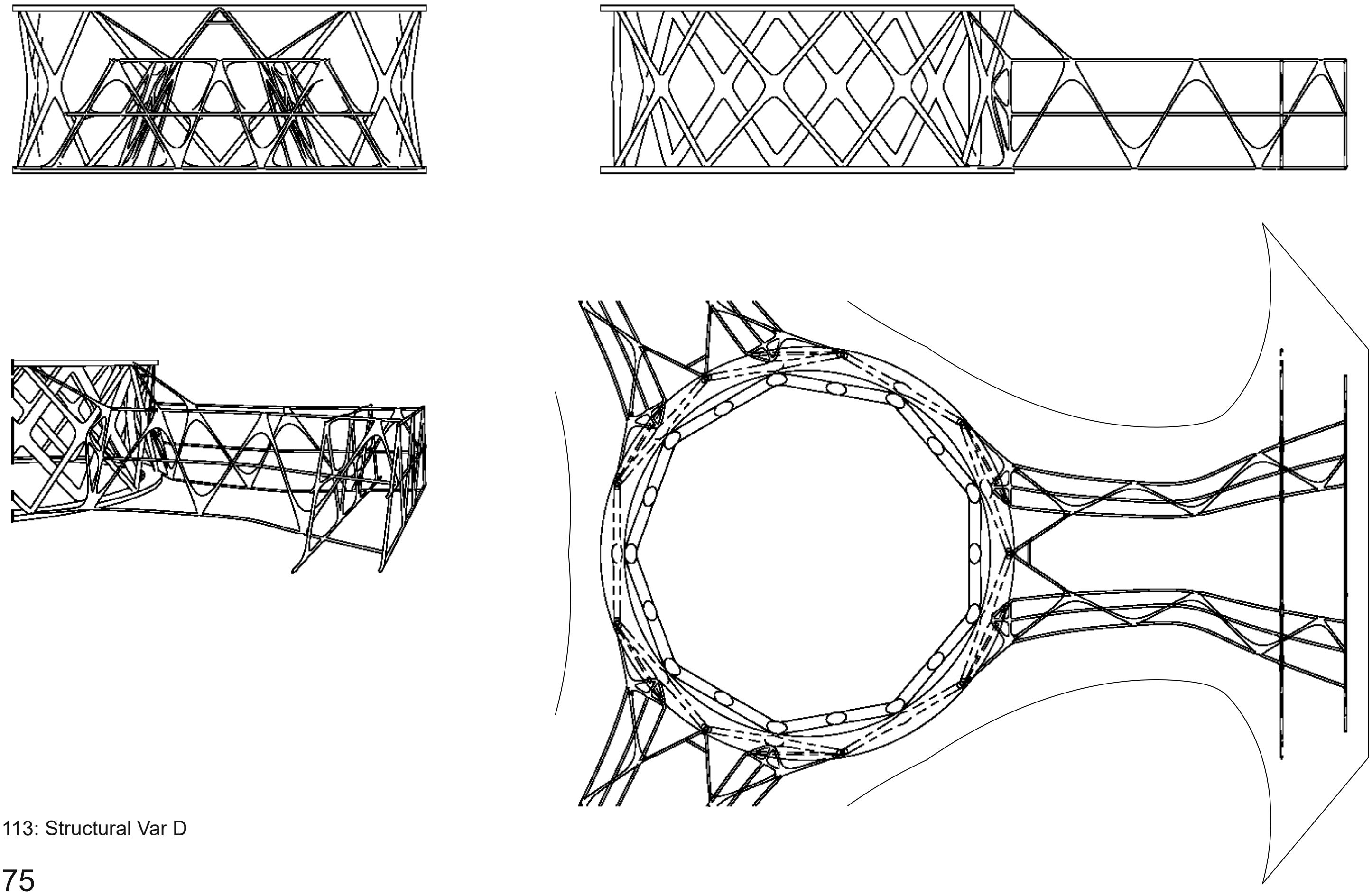


112: Structural Var C

Var D

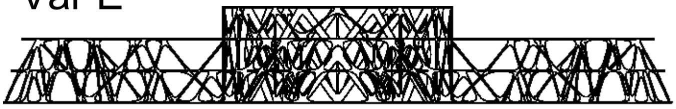


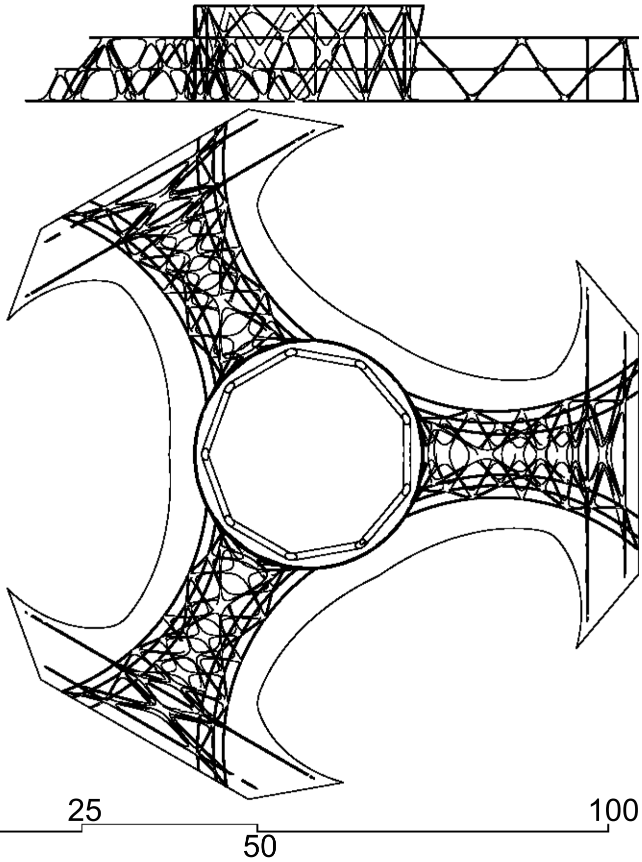
Var D'

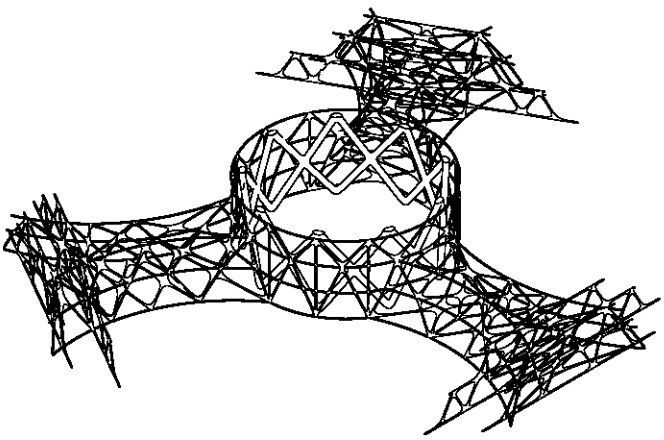


113: Structural Var D

Var E

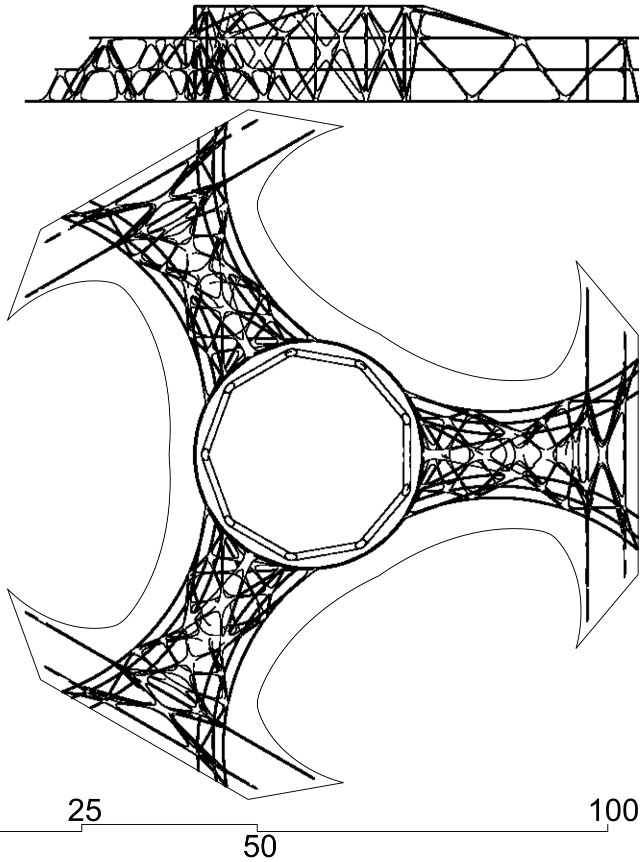


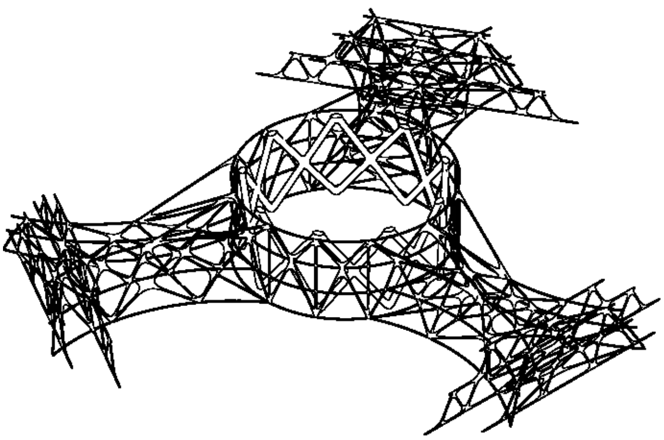




114: Structural Var E

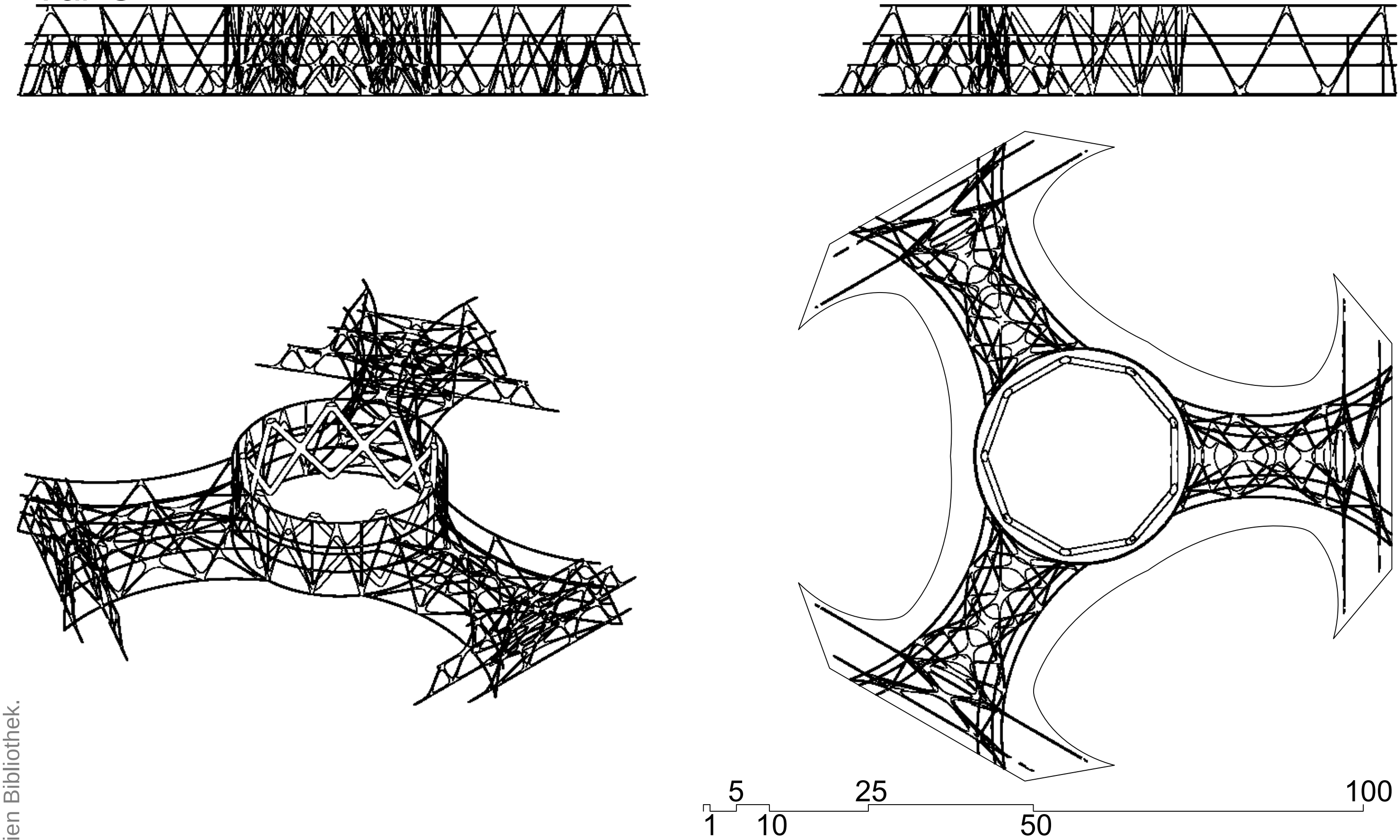
Var F





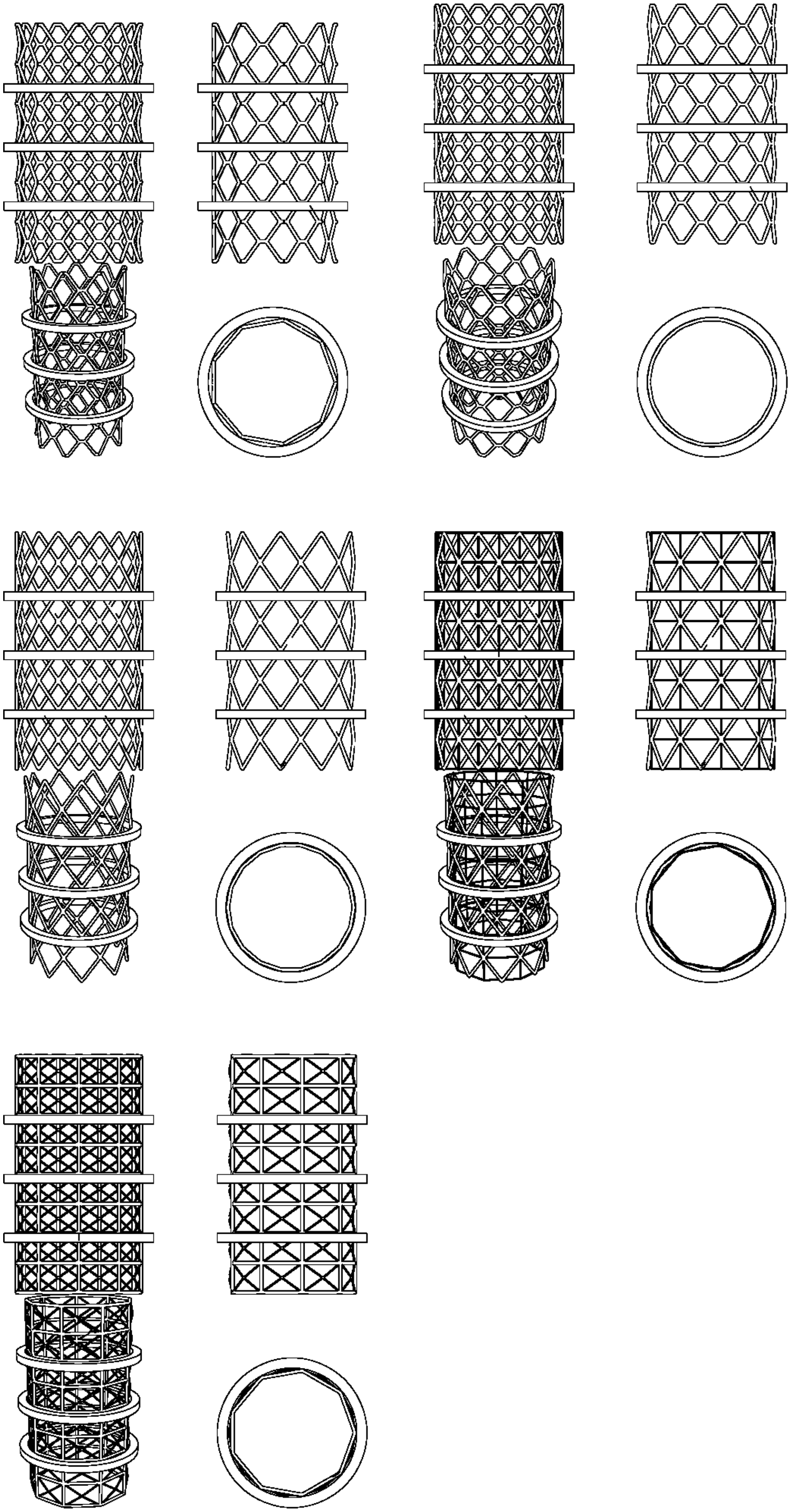
115: Structural Var F

Var G



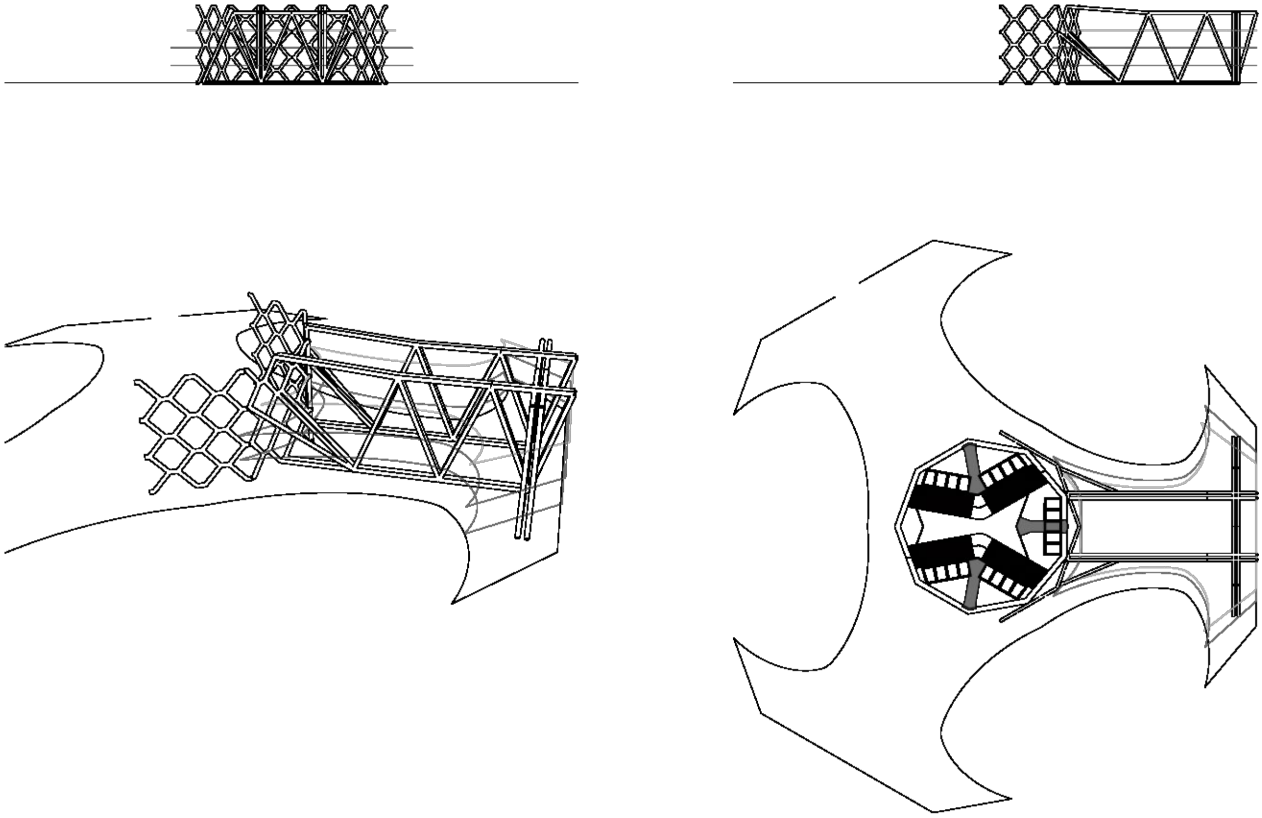
116: Structural Var G

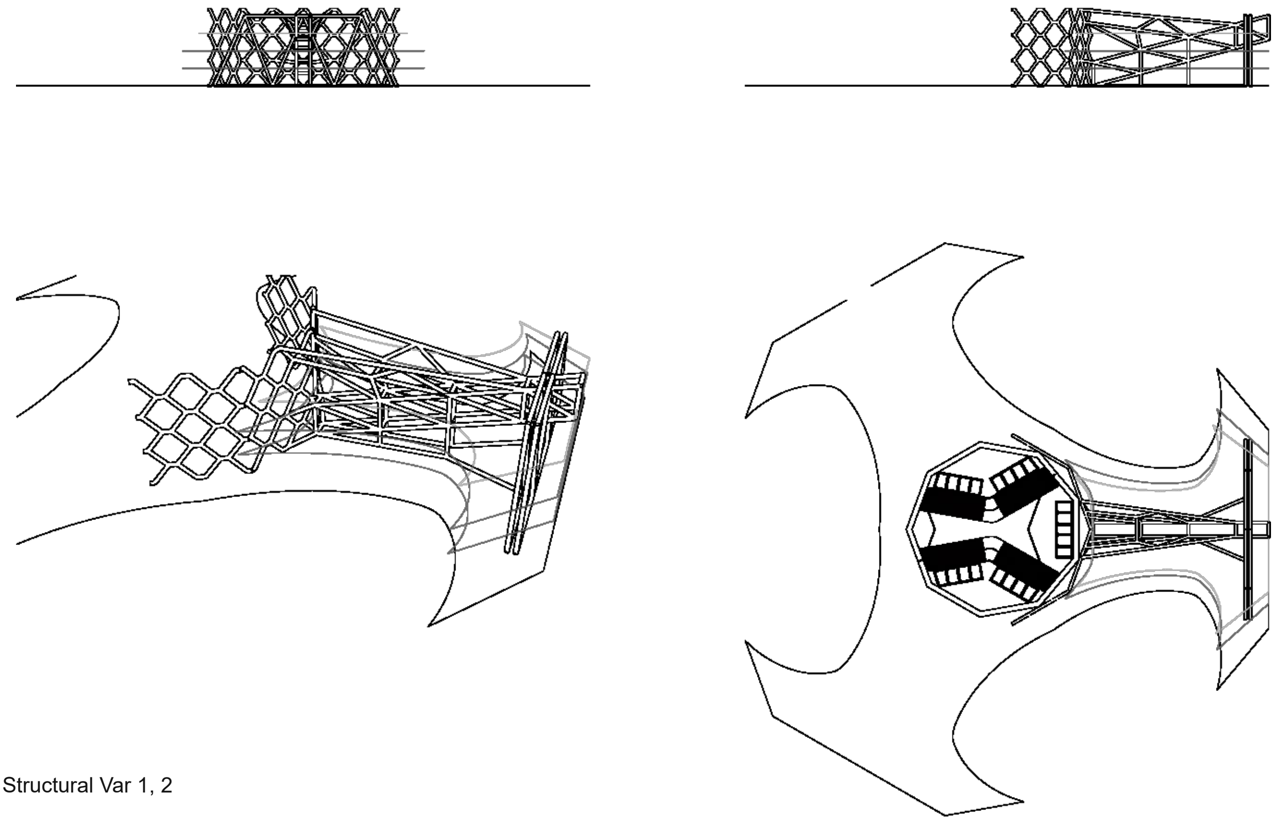
Inner Core structural variations



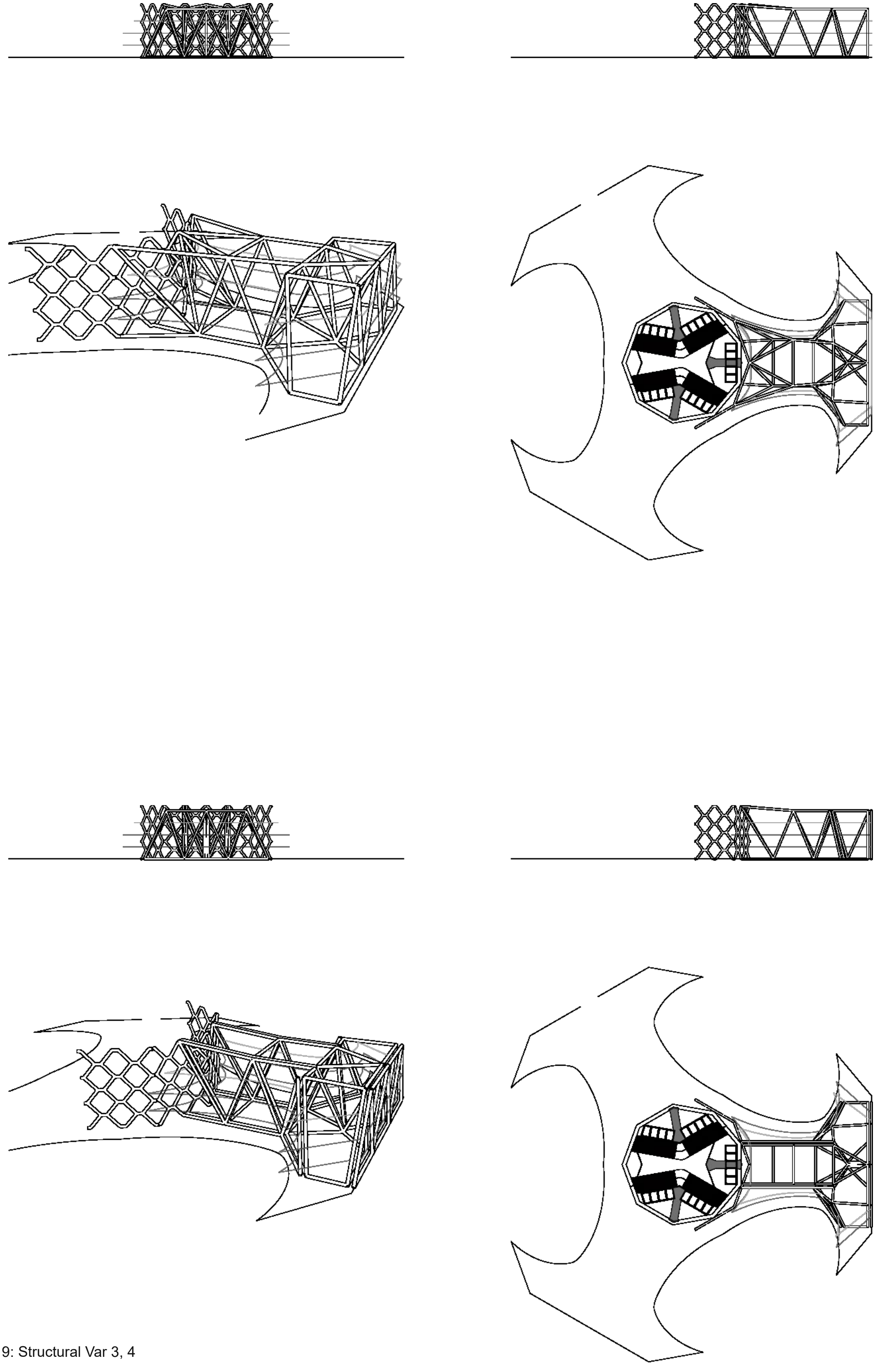
117: Structural Var Inner Core - Support for Consoles

pre-final structural variations

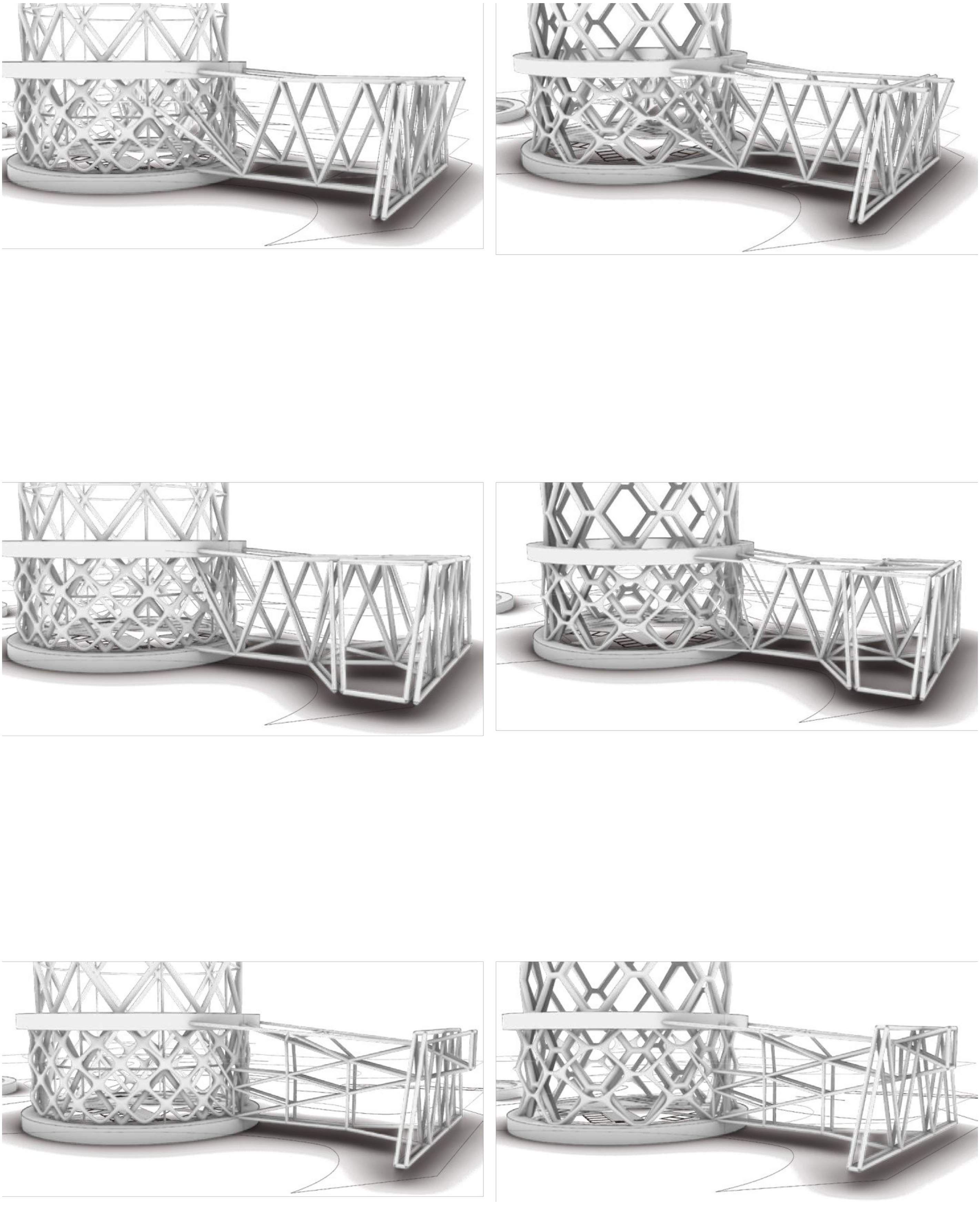




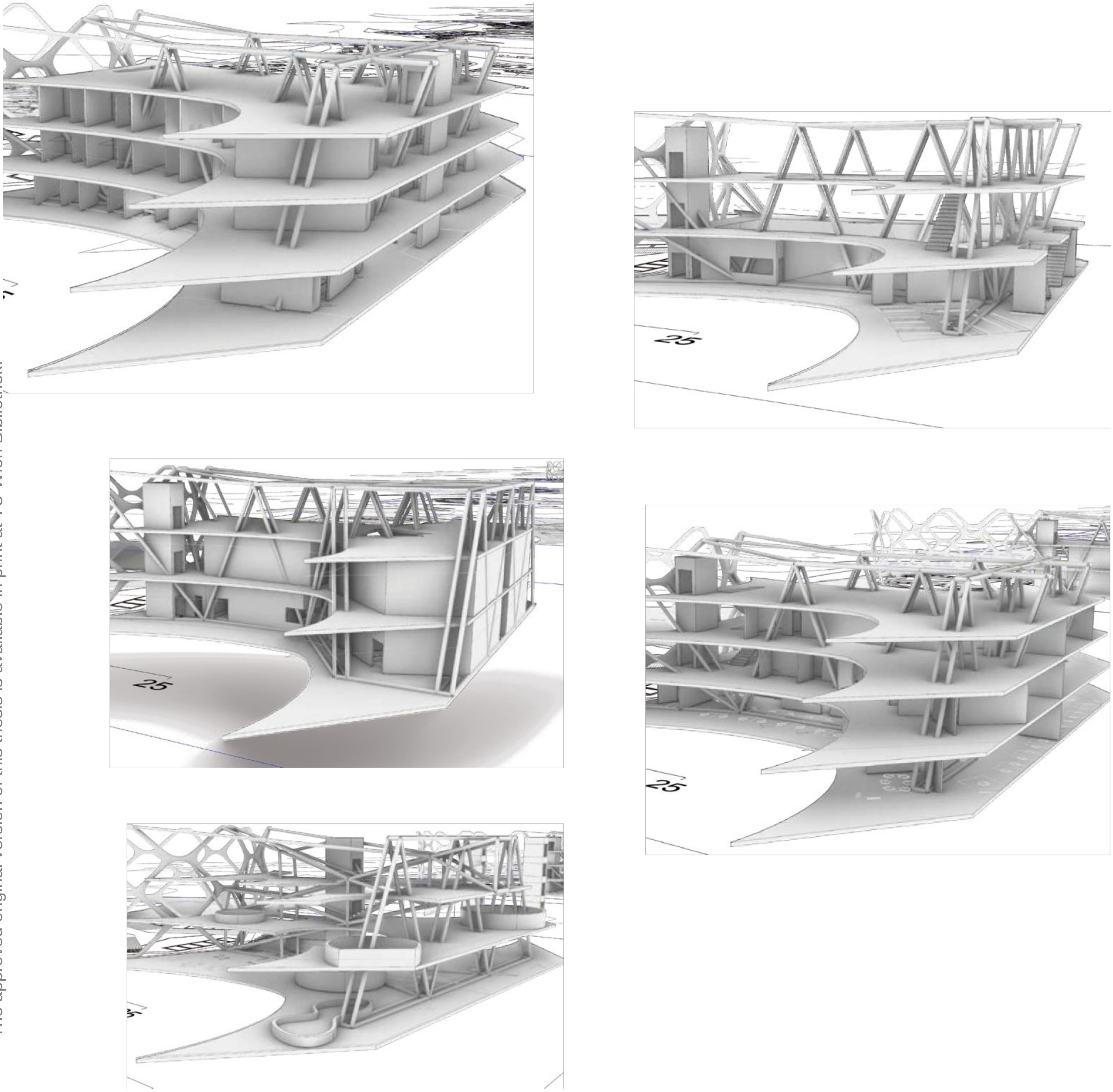
118: Structural Var 1, 2



119: Structural Var 3, 4

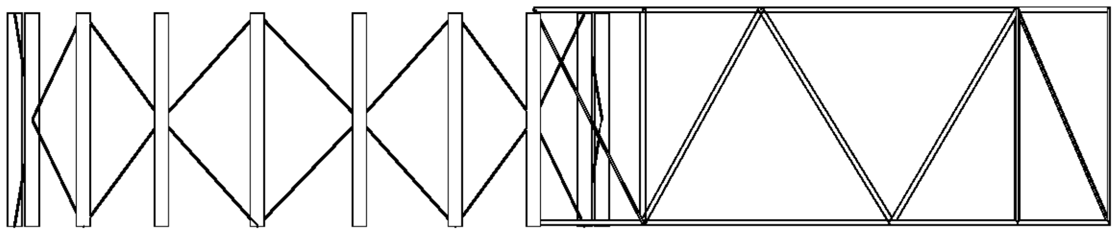


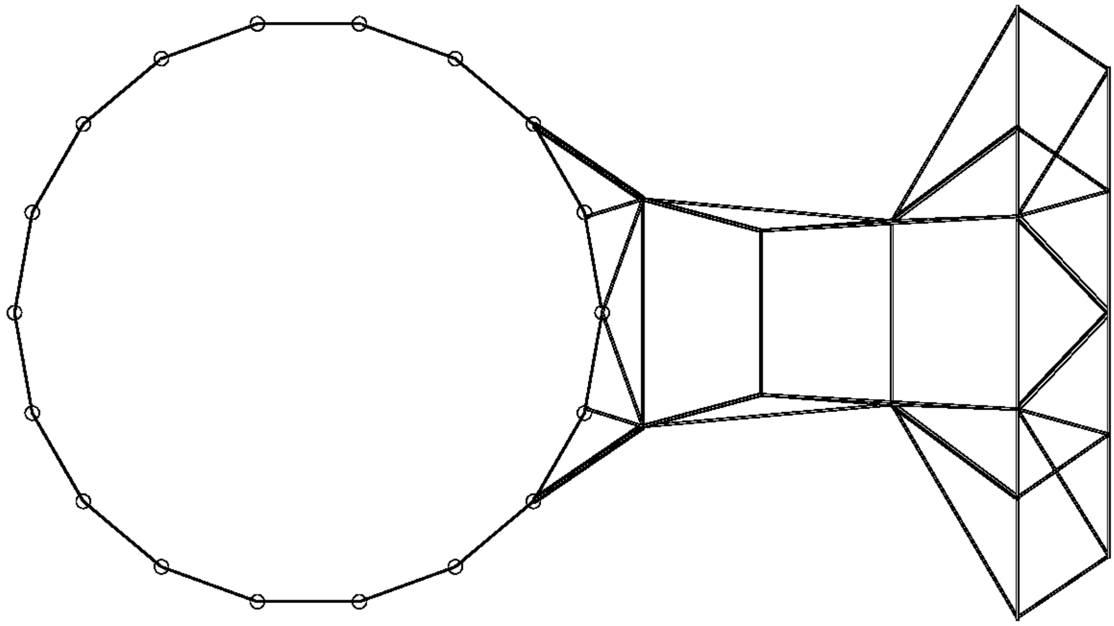
120: Structural Variations Combined

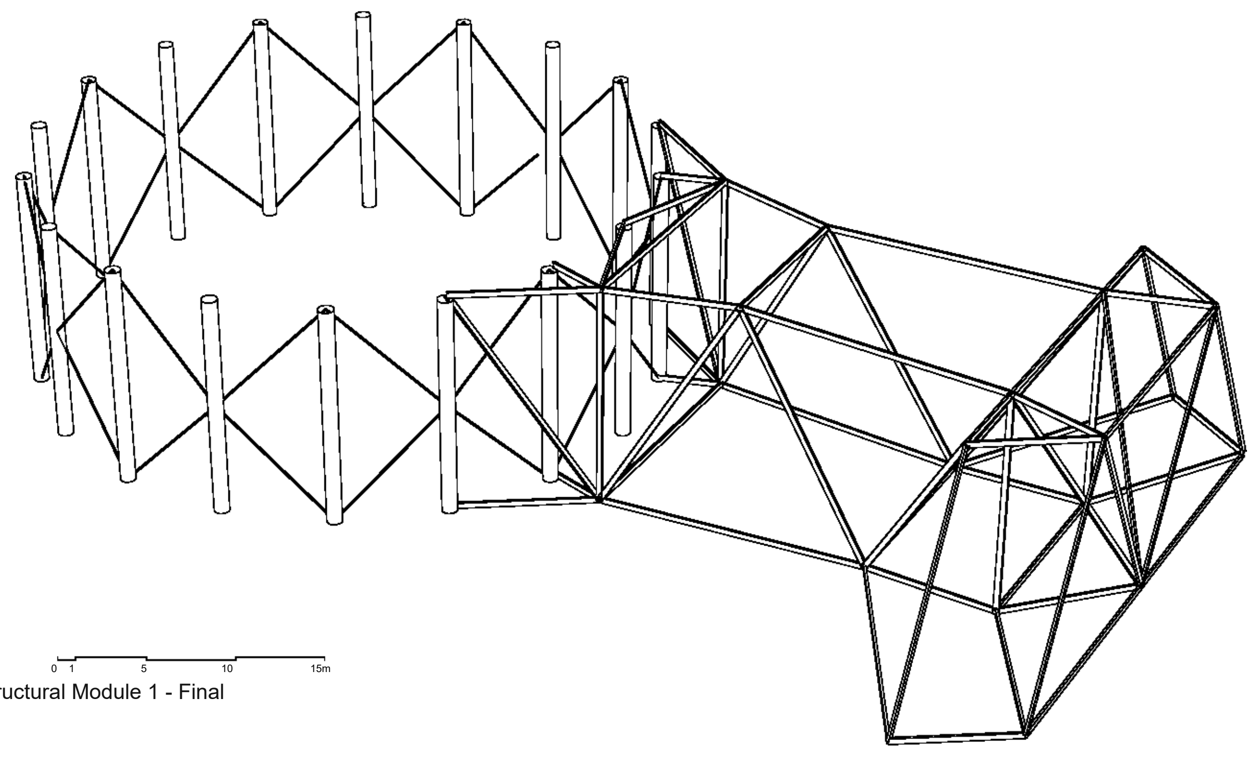


121: Structural Variations in first Spacial Models

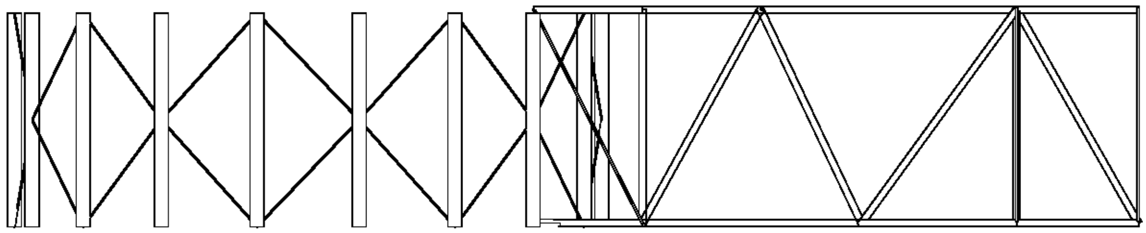
4.8 Final Structural Modules

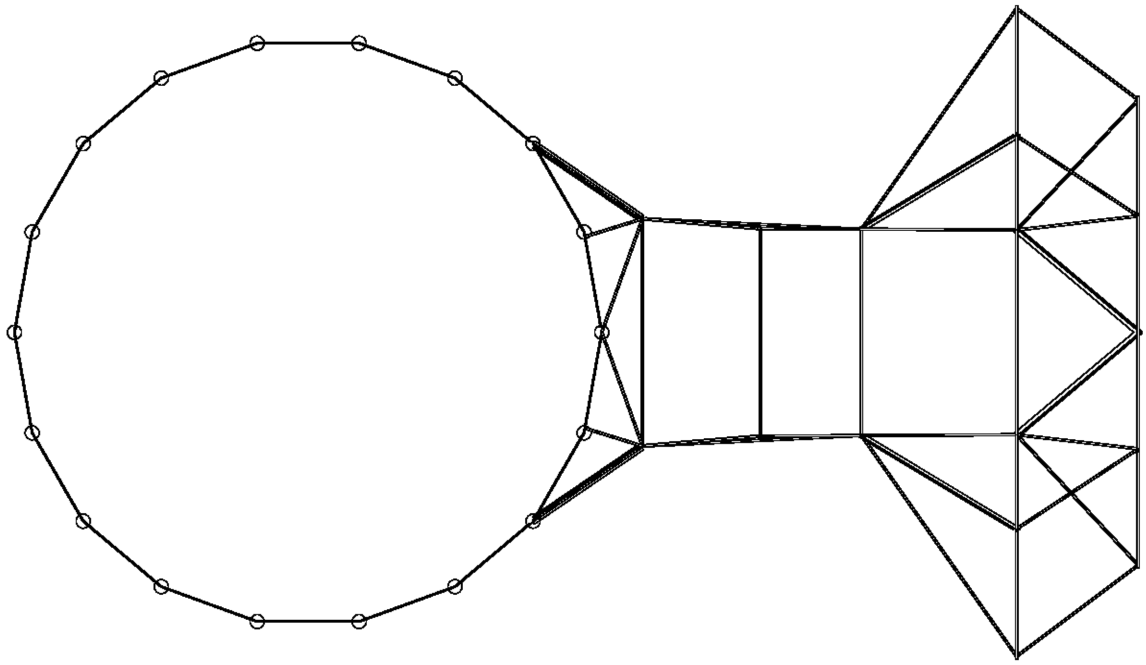


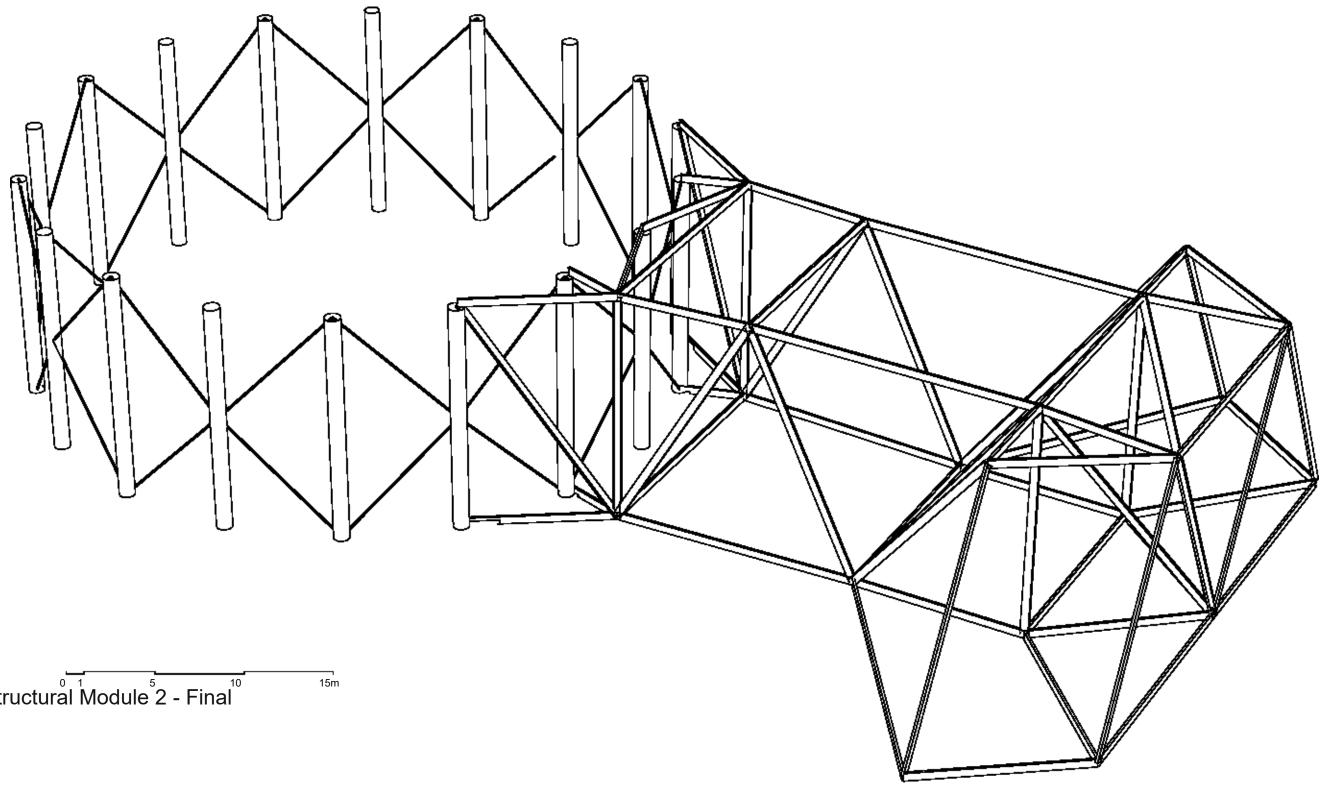




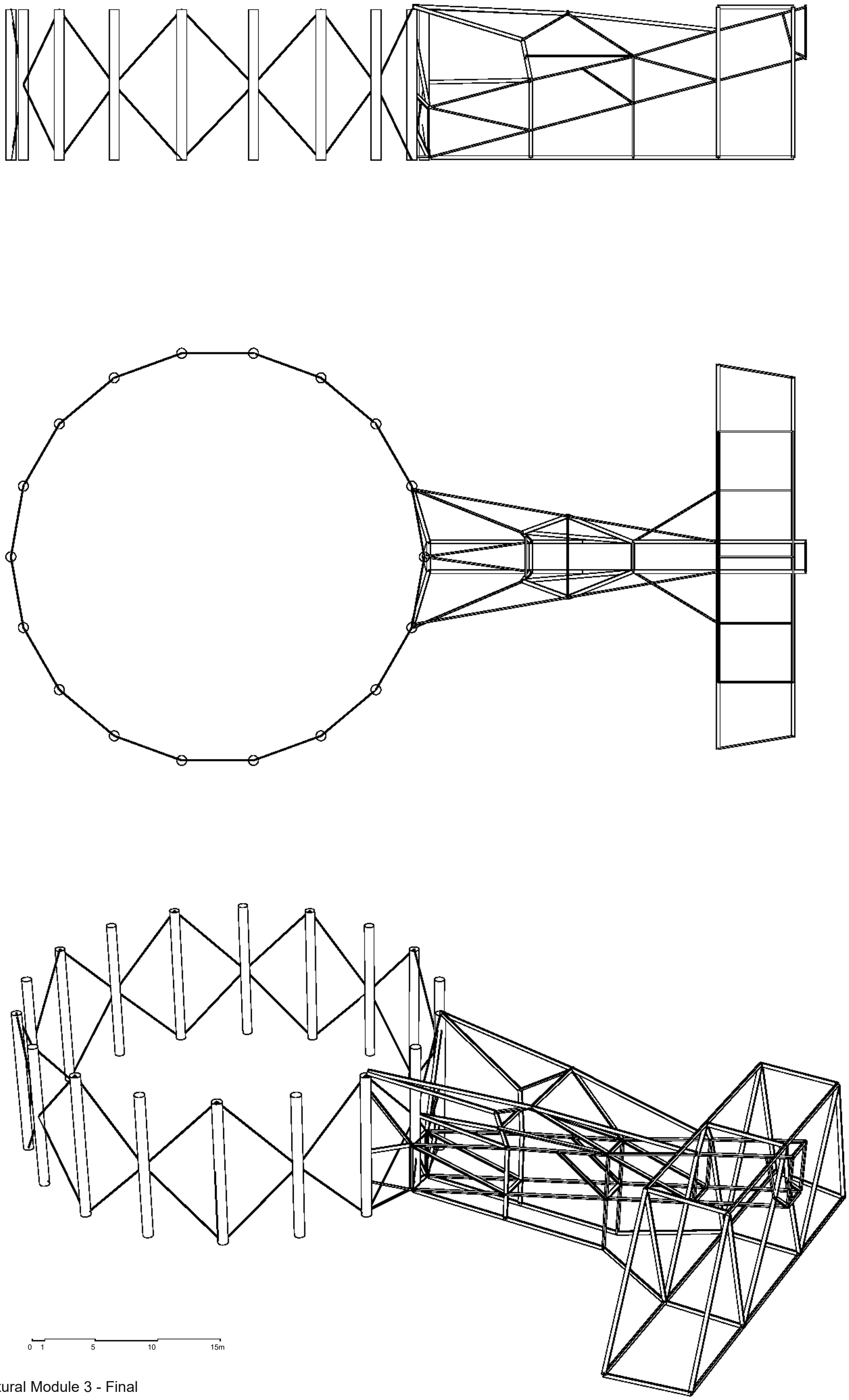
122: Structural Module 1 - Final







123: Structural Module 2 - Final



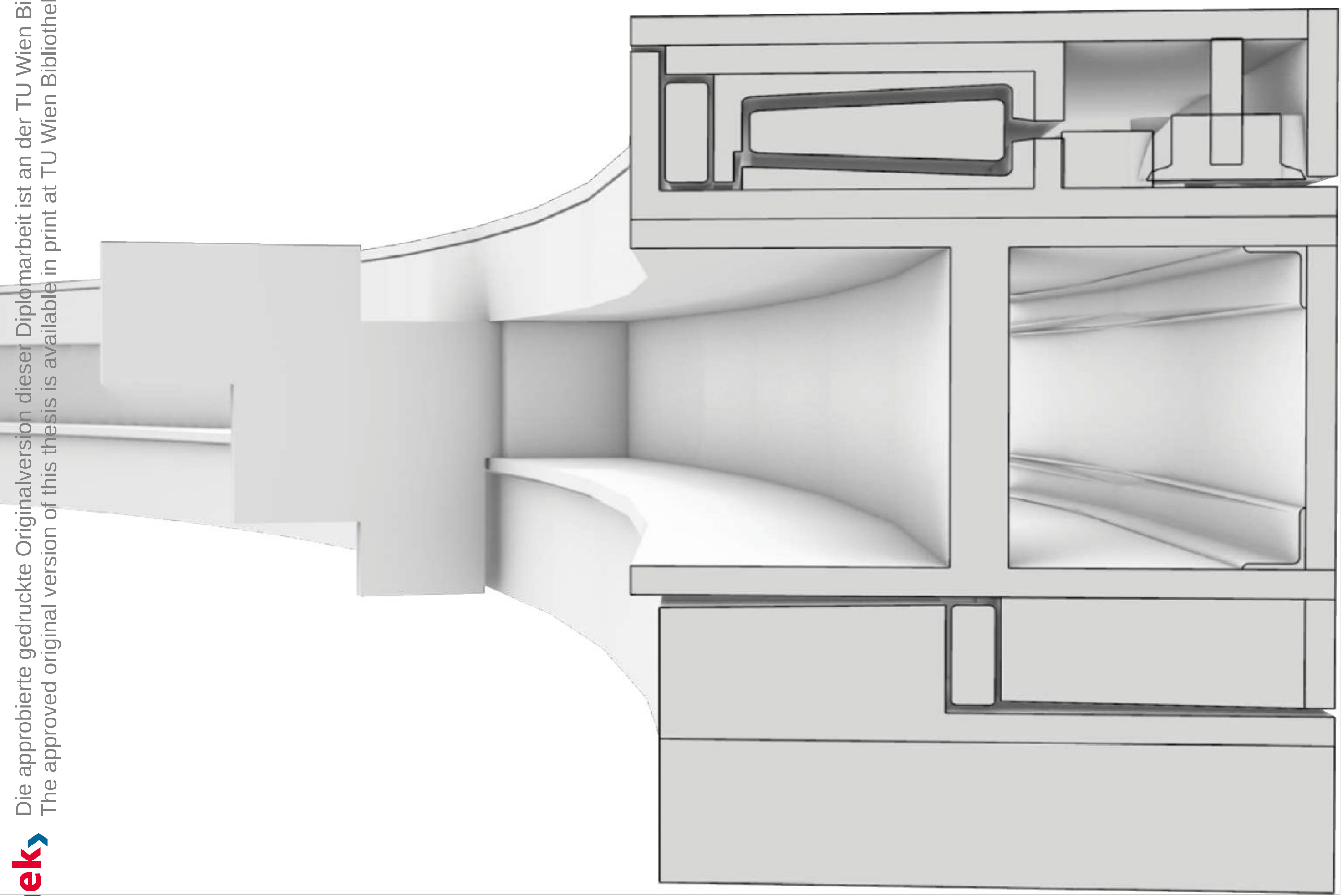
124: Structural Module 3 - Final

5 Results

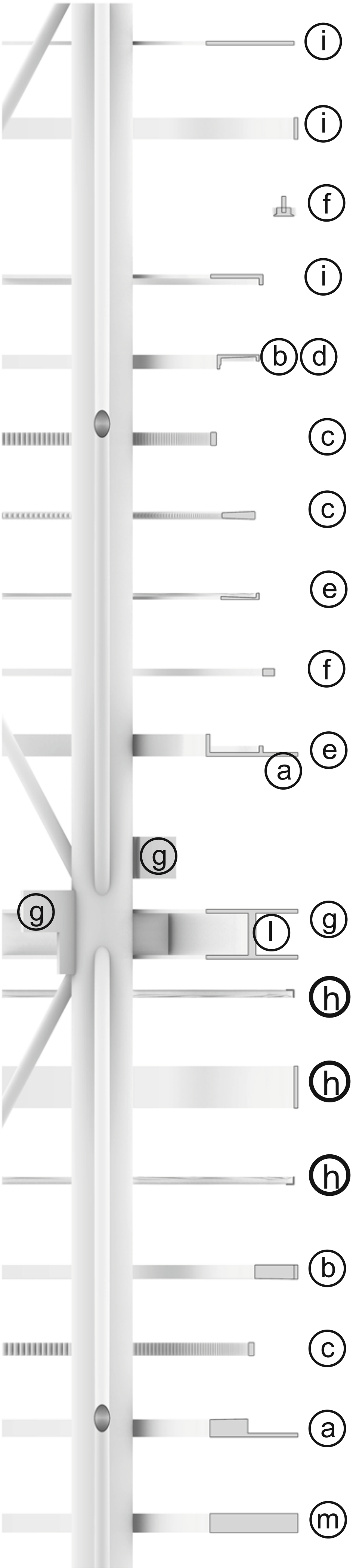
5 Results

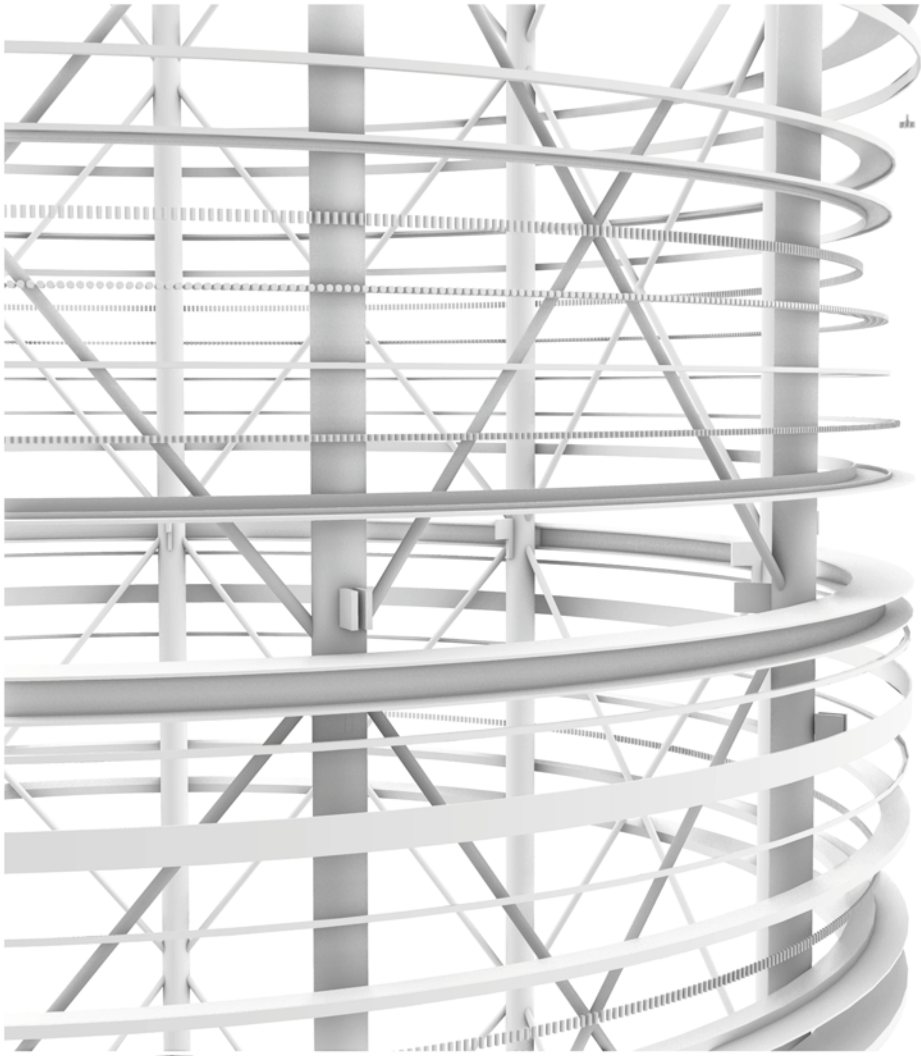
5.1 Final Bearing with Console and Duct
5.2 Floorplans and Perspectives
5.3 Elevations and Sections
5.4 Details

5. 1 Final Bearing with Console and Duct



125: Bearing Perspective Section - Final





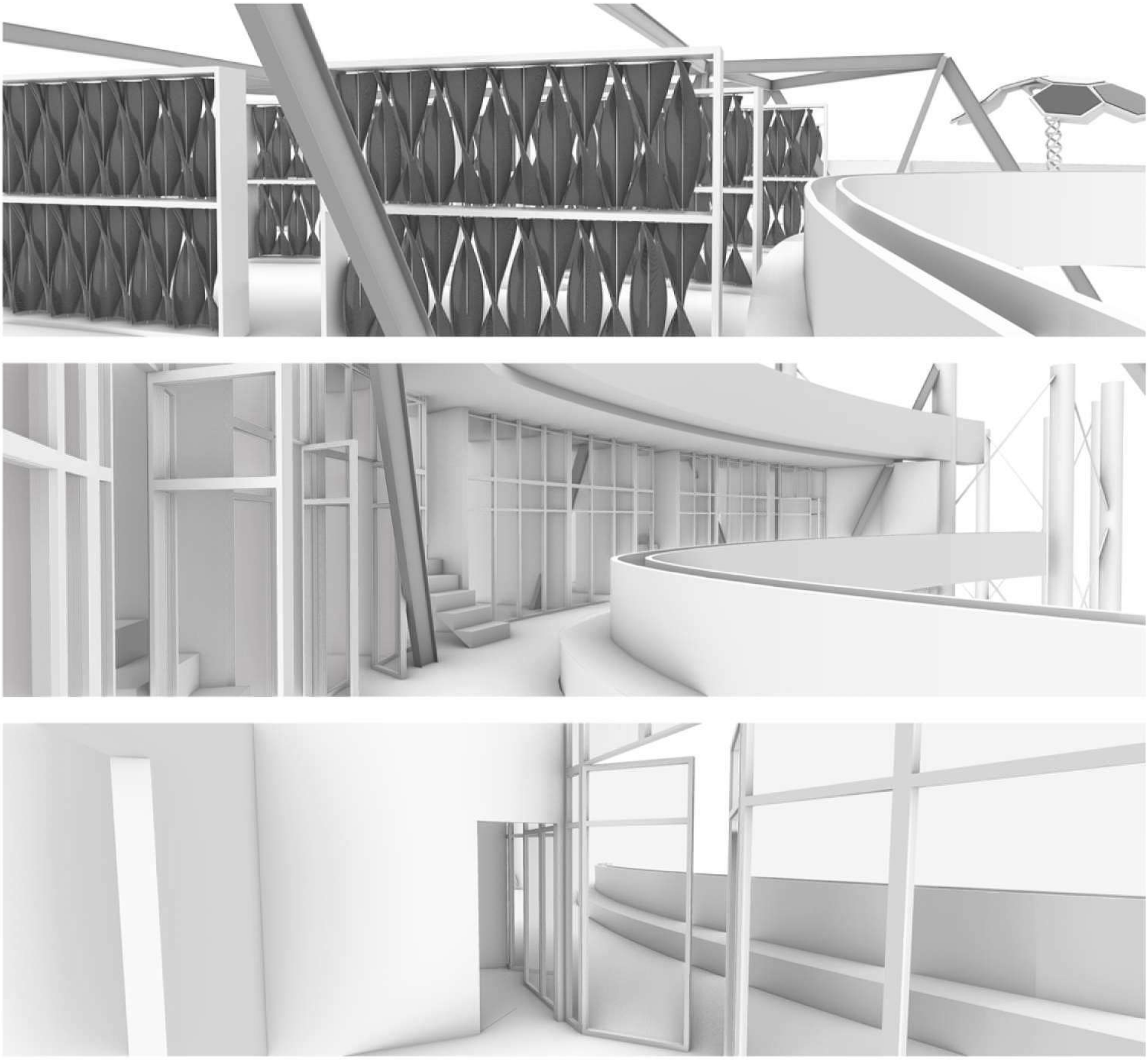
General bearing assembly

a) inner ring
b) outer ring
c) rolling elements (balls/ cylinders)
d) upper ring C-profile
e) lower ring C+L-profile
f) gear (outside)
g) flanches and I beam
h) duct and cover plate L-profile
i) cover plate top
j) spacer plate
k) console
l) utility space ac plumbing etc.
m) circular tension beam

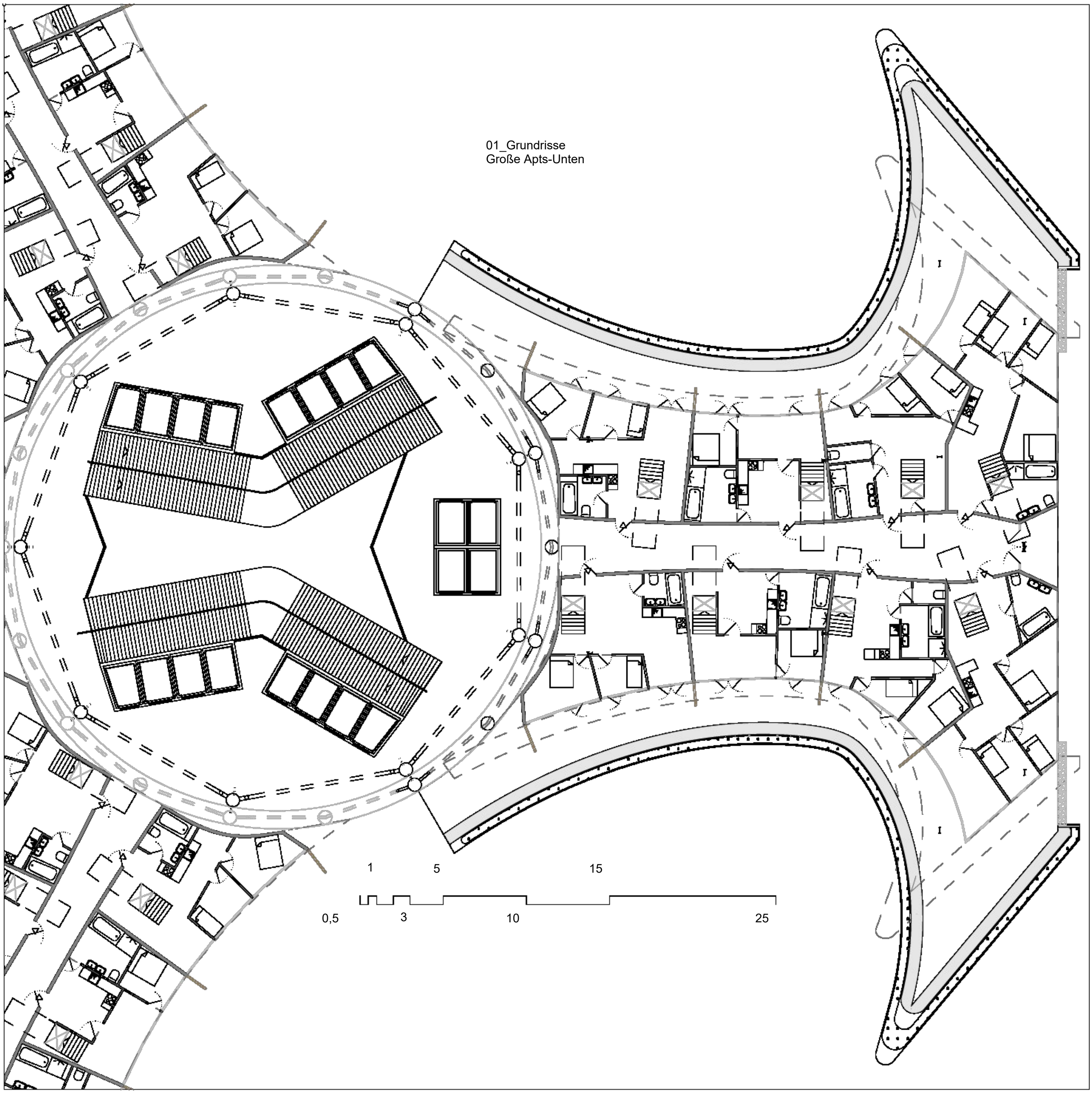
126: Bearing Perspective Explosion and Assembly

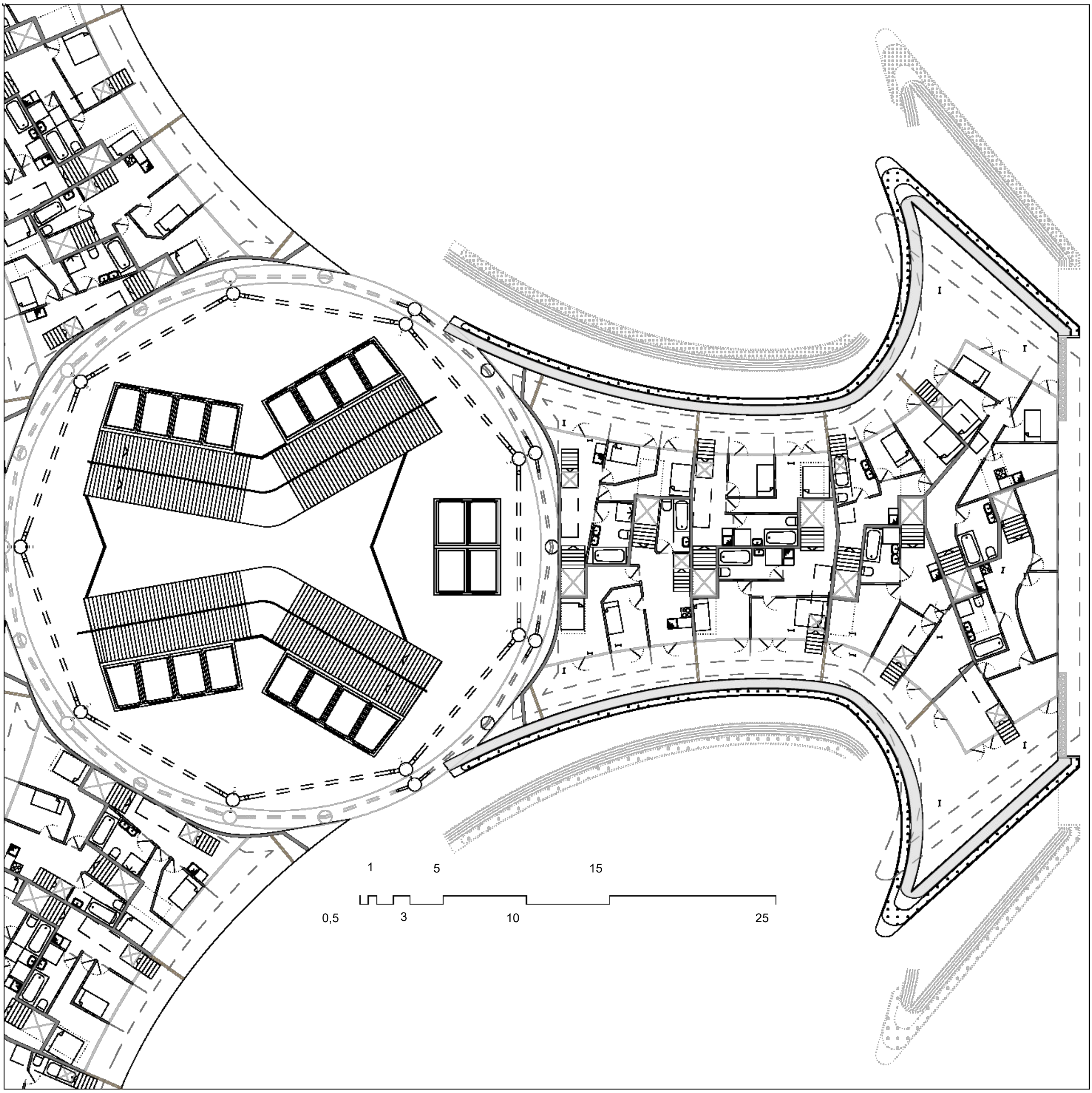
5.2 Floorplans and Perspectives

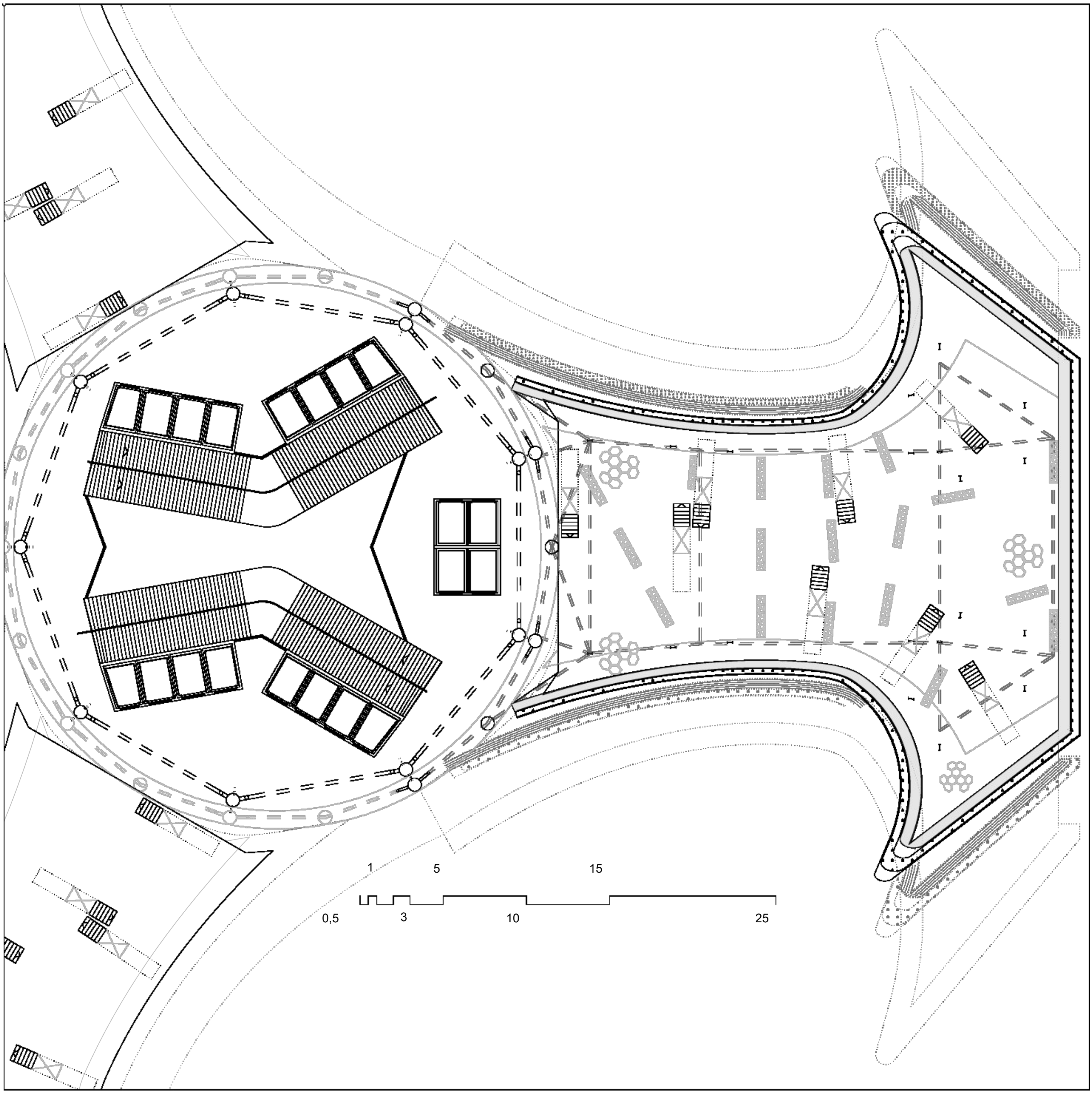
Large Apartments



127: First Person Perspectives - Large Apartments

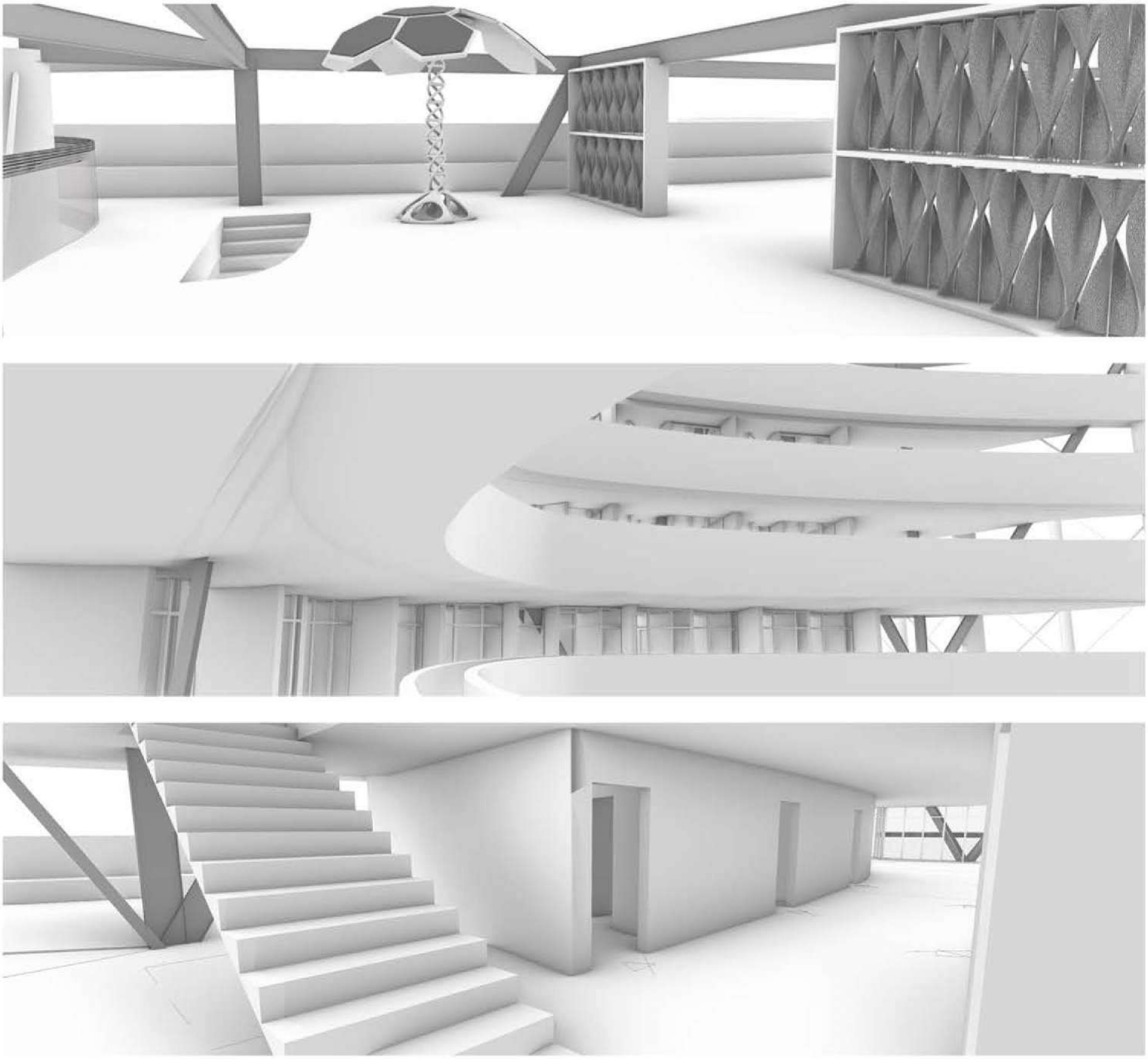

01_Grundrisse
Große Apts-Unten
1
5
15
0,5
3
10
25


1
5
15
0,5
3
10
25

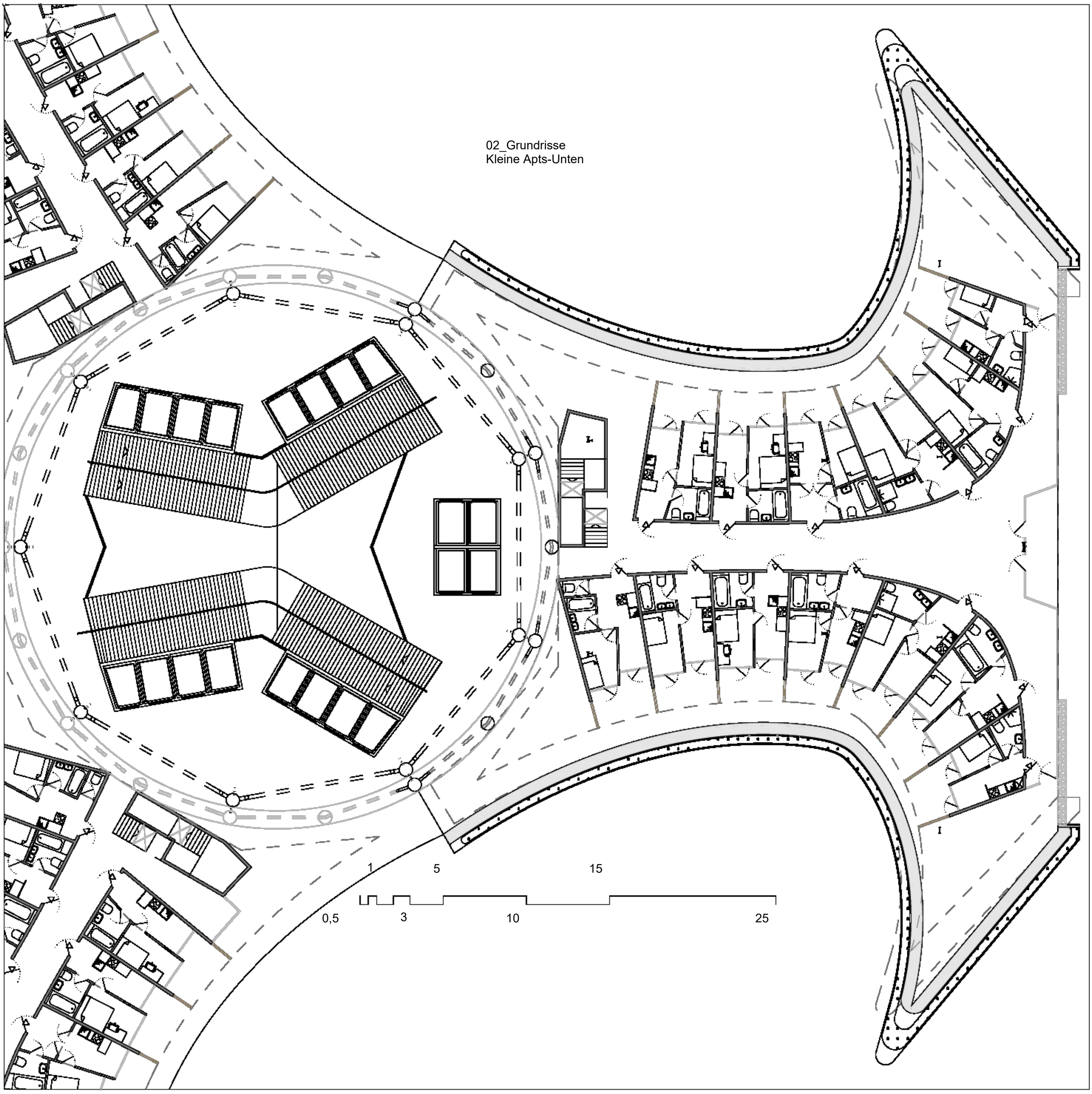


128: Floorplans - Large Apartments

Smaler Apartments

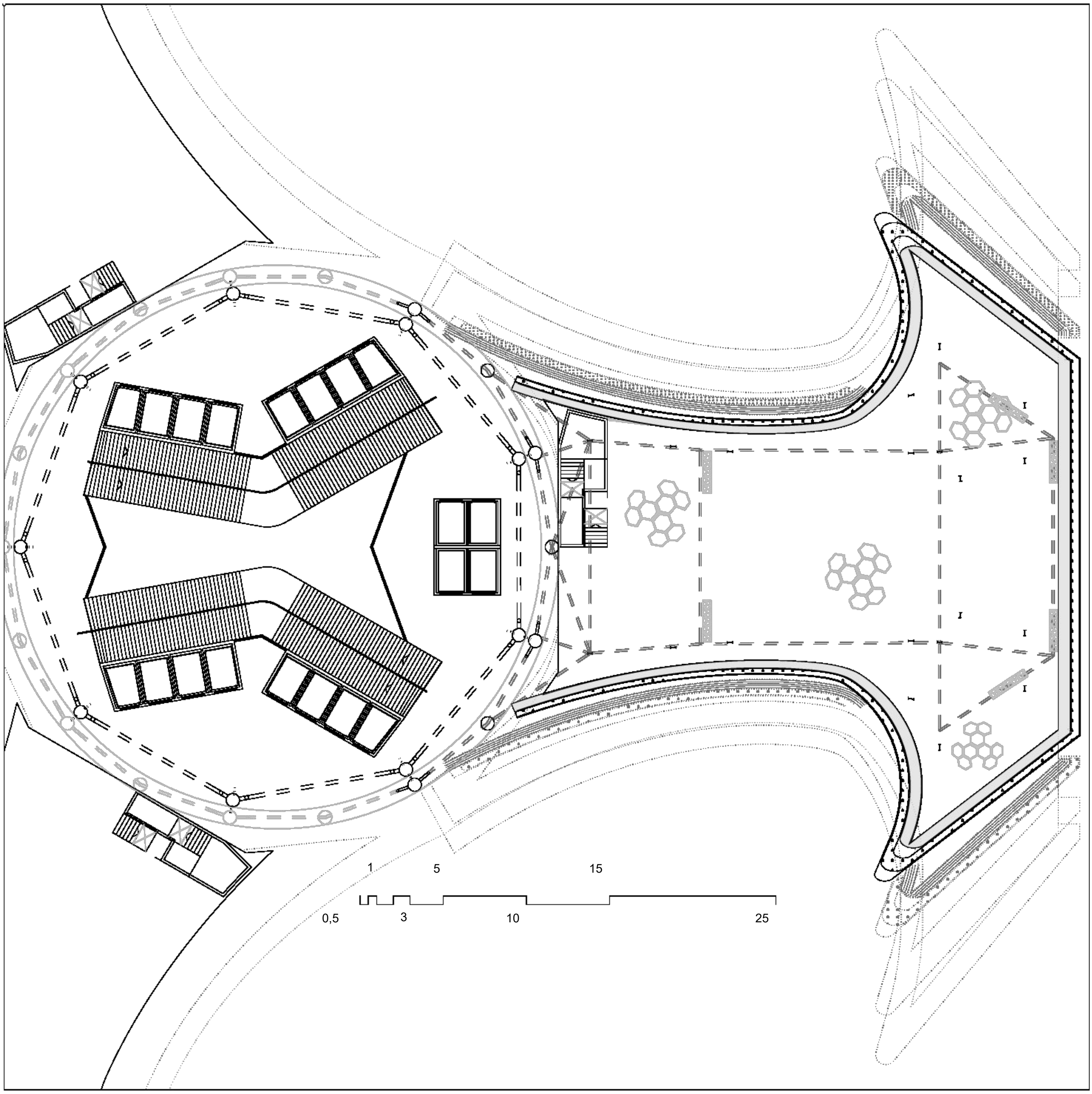


129: First Person Perspectives - Smaler Apartments



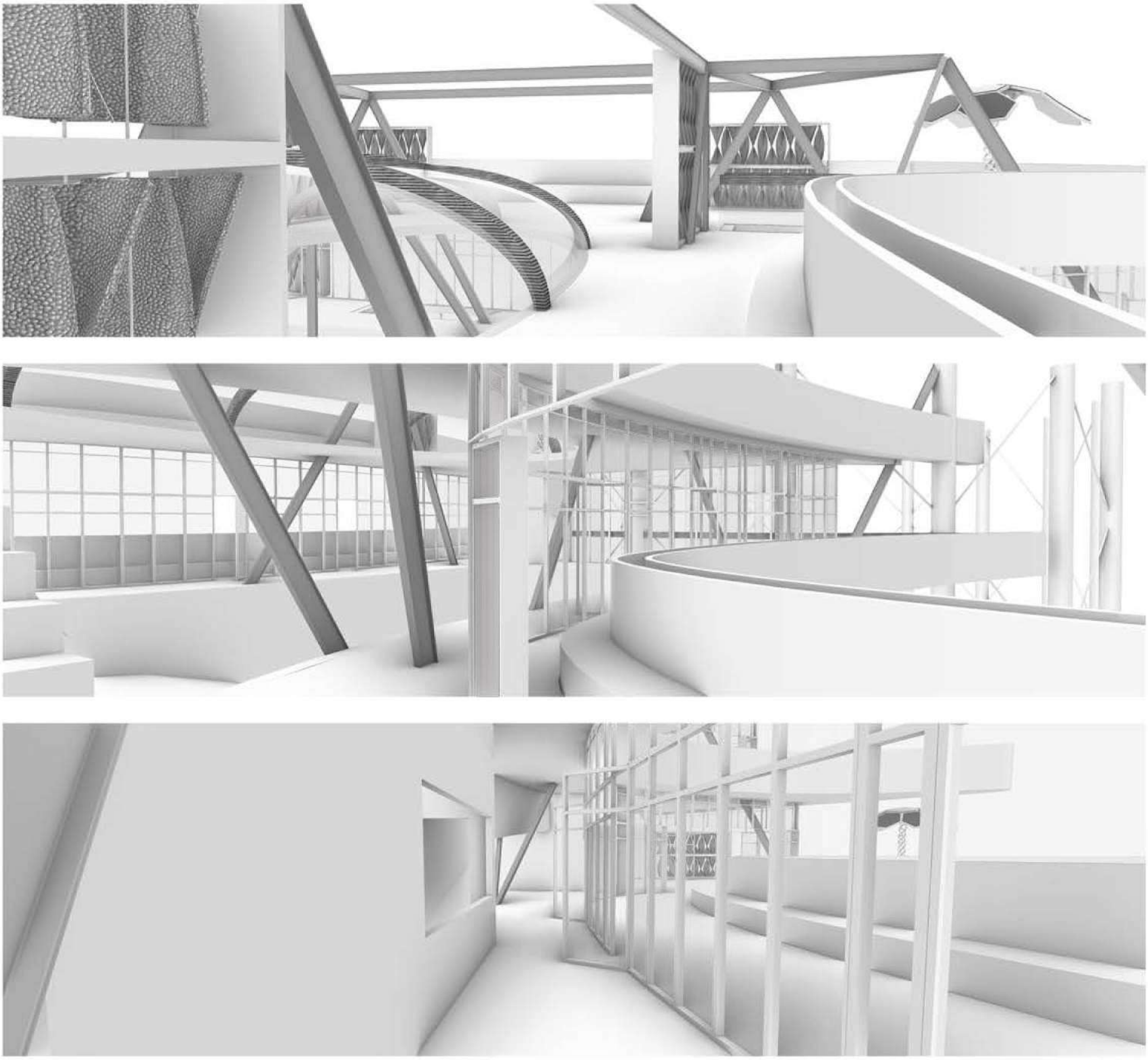
02_Grundrisse
Kleine Apts-Unten
1
5
15
0,5
3
10
25


1
5
15
0,5
3
10
25

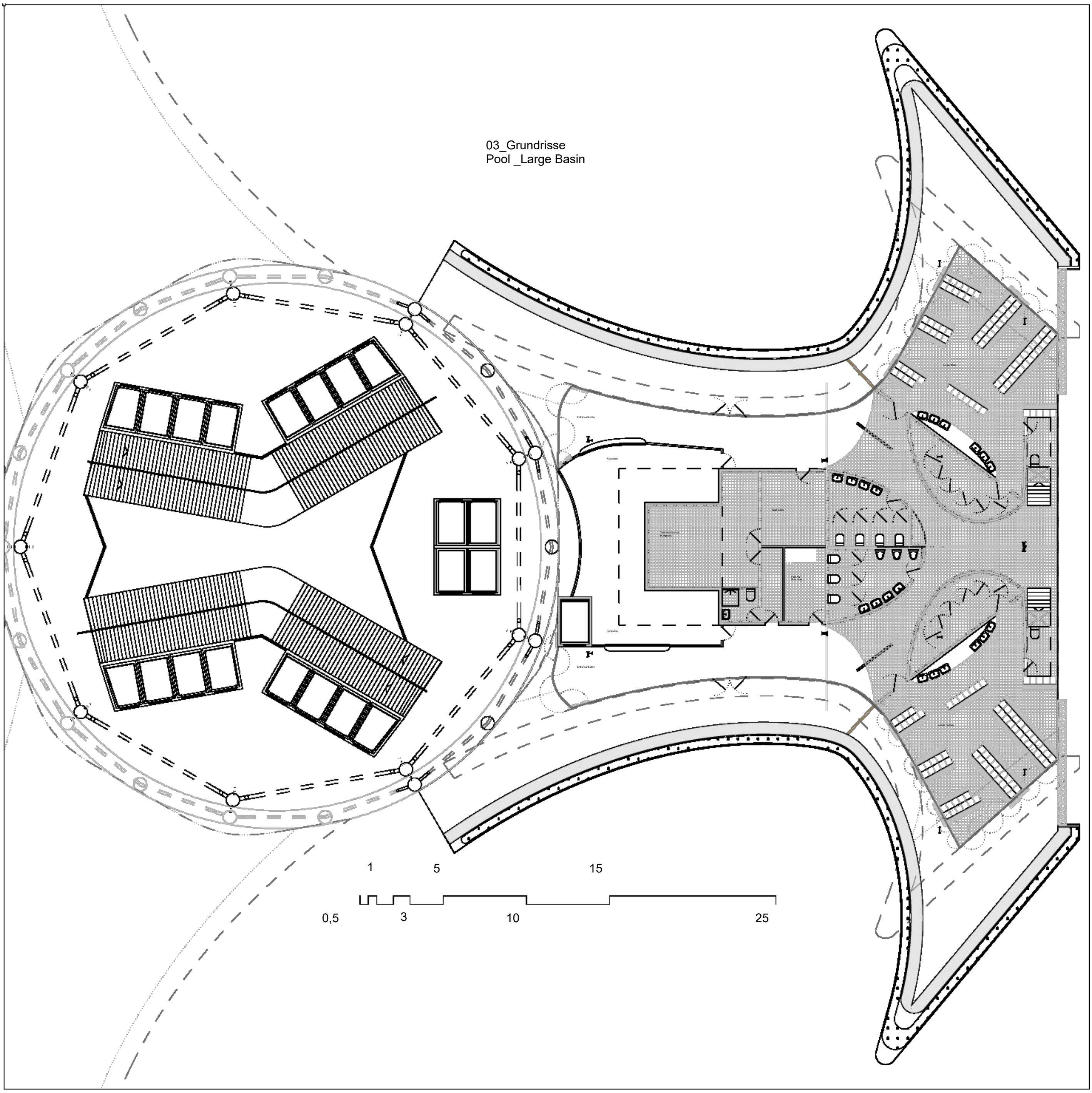


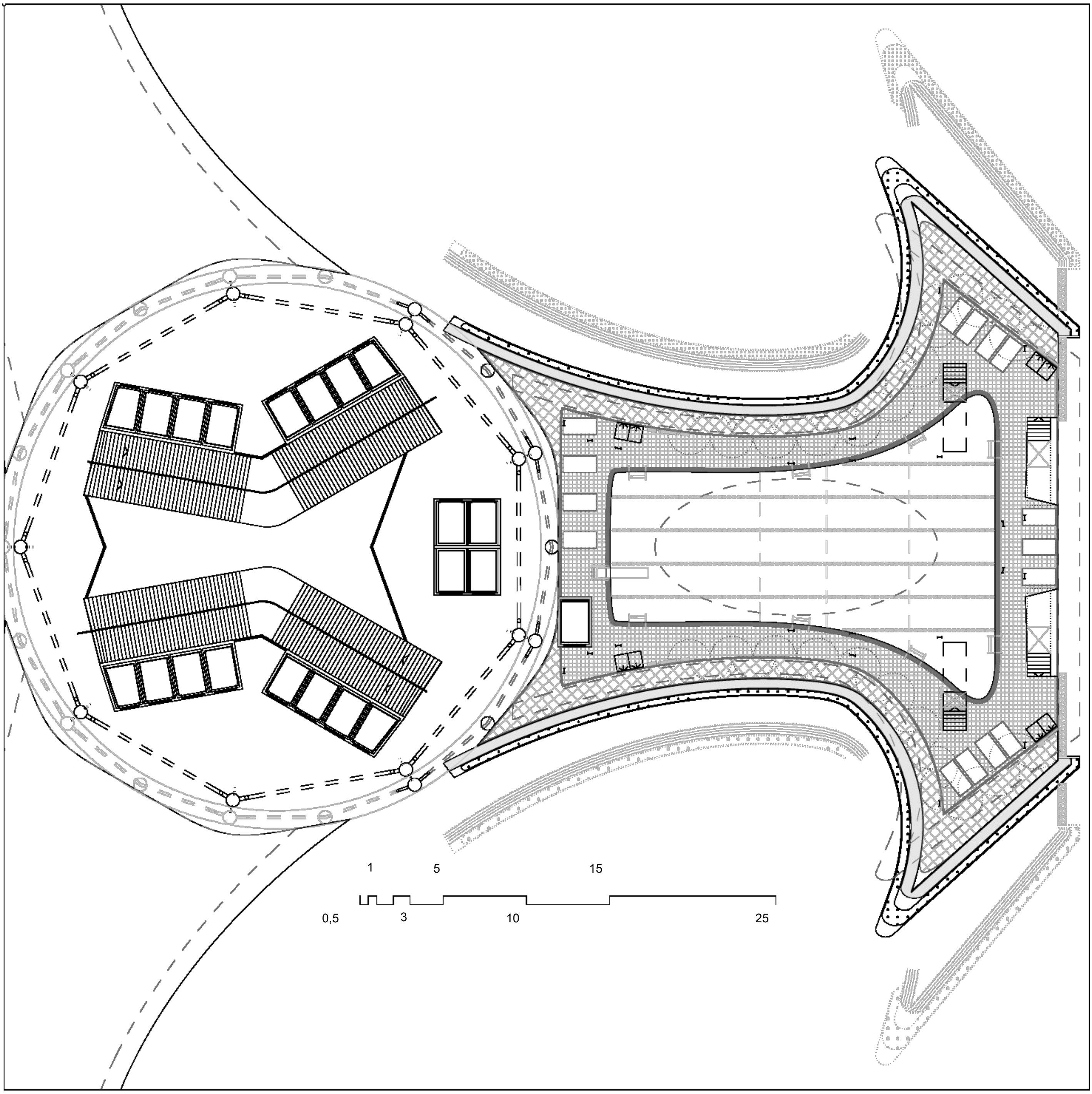
130: Floorplans - Smaler Apartments

Large Basin - Pool Module 1

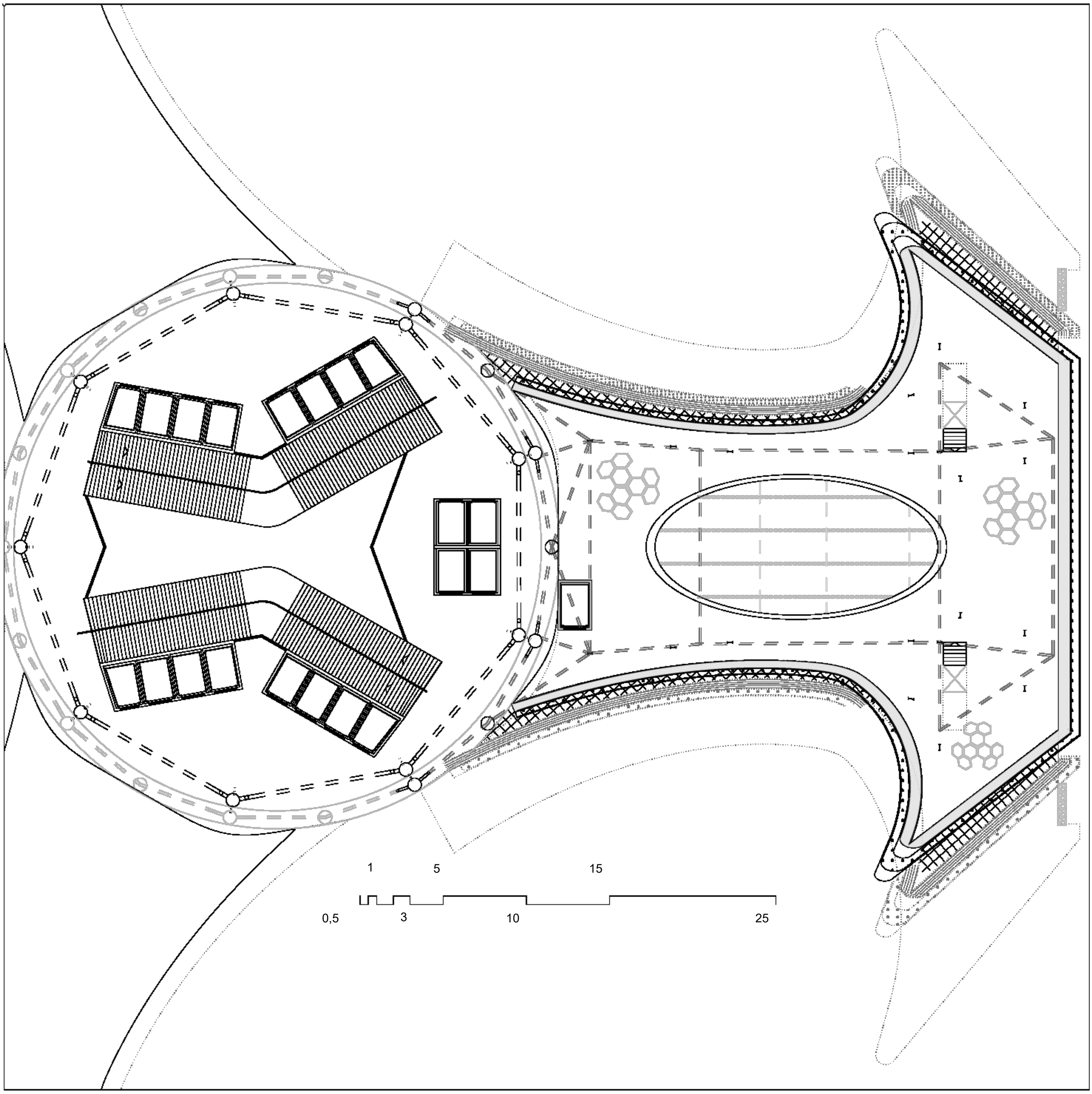


131: First Person Perspectives - Large Basin

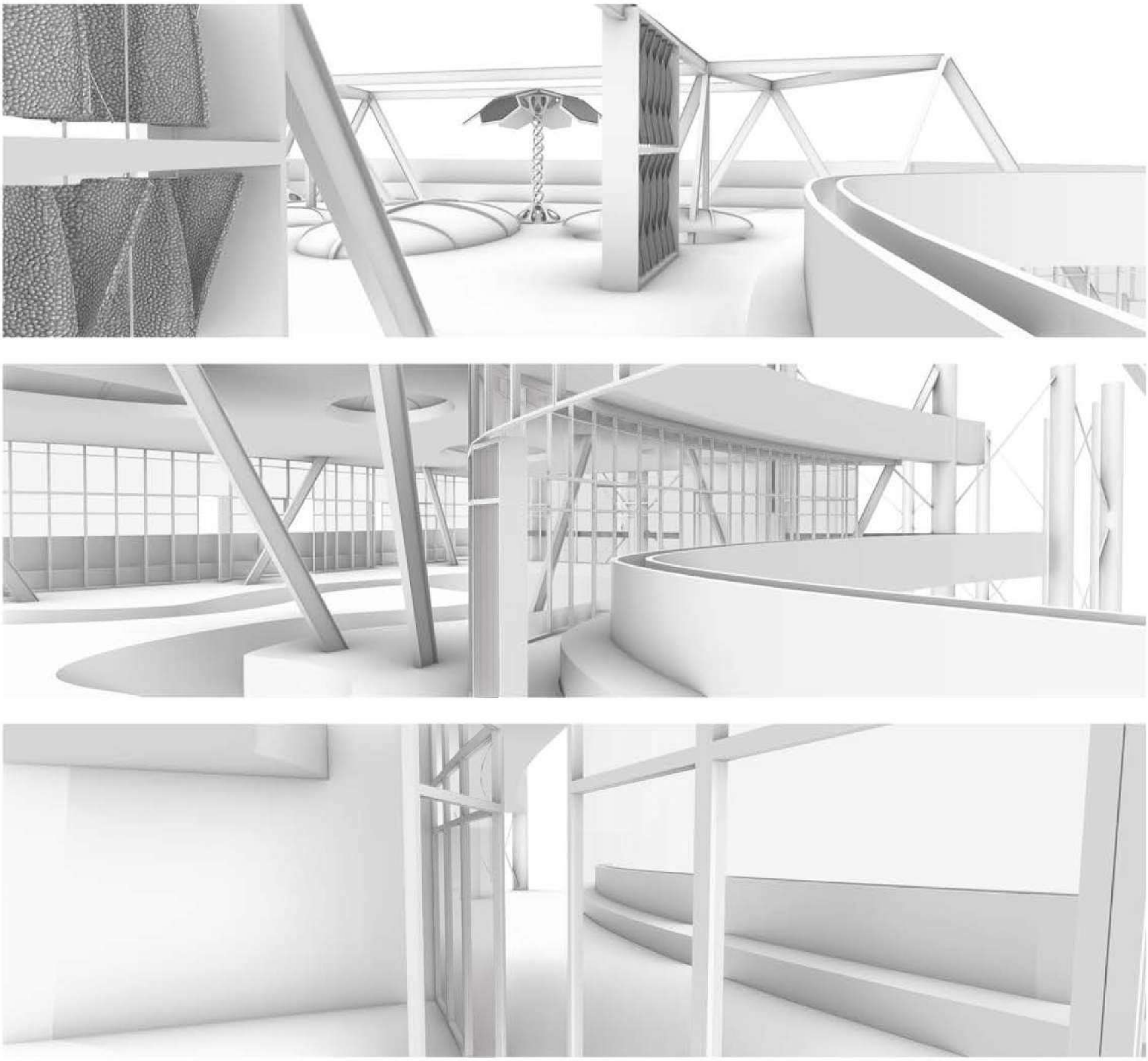

03_Grundrisse
Pool _Large Basin
1
5
15
0,5
3
10
25



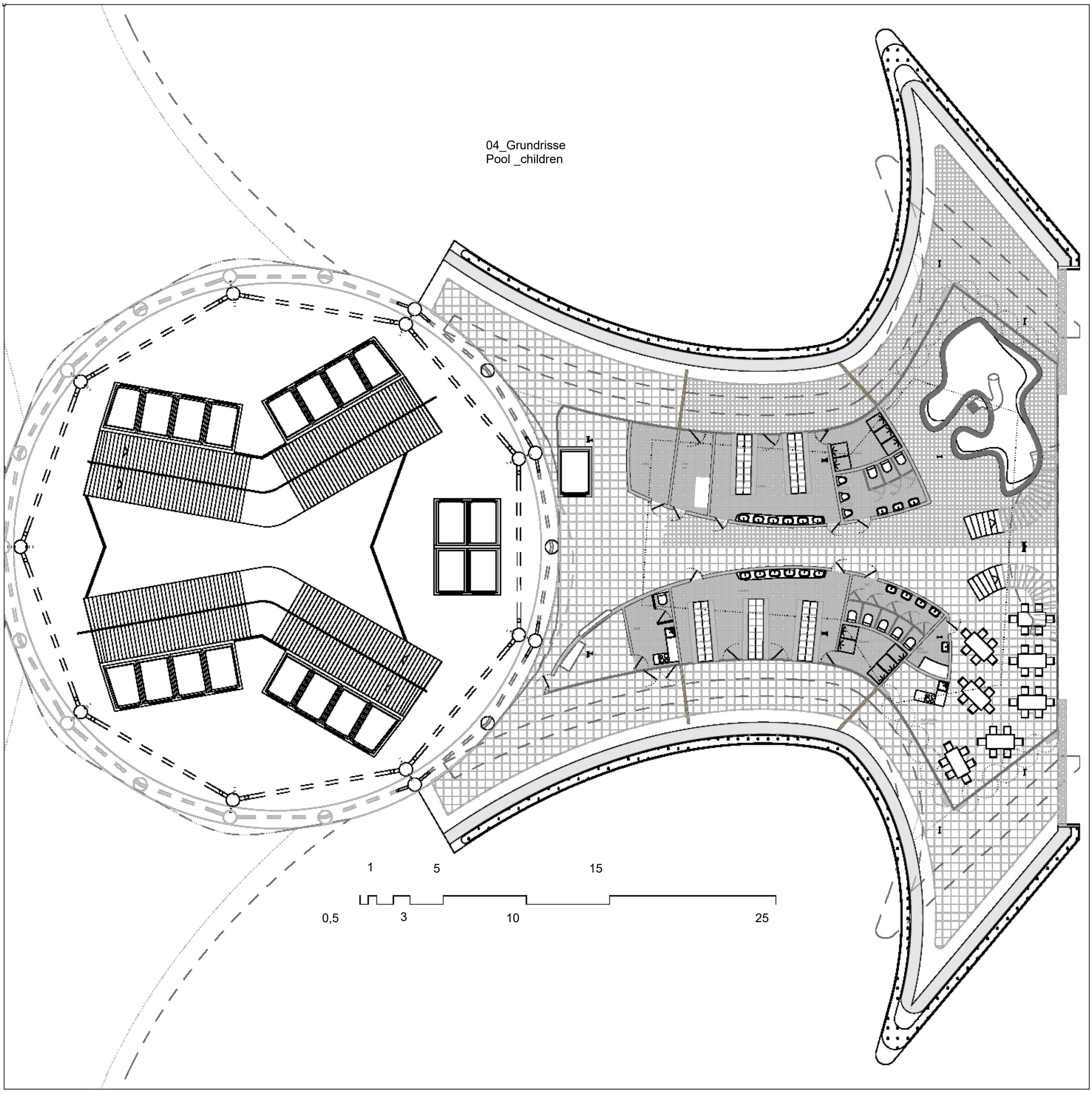
132: Floorplans - Large Pool

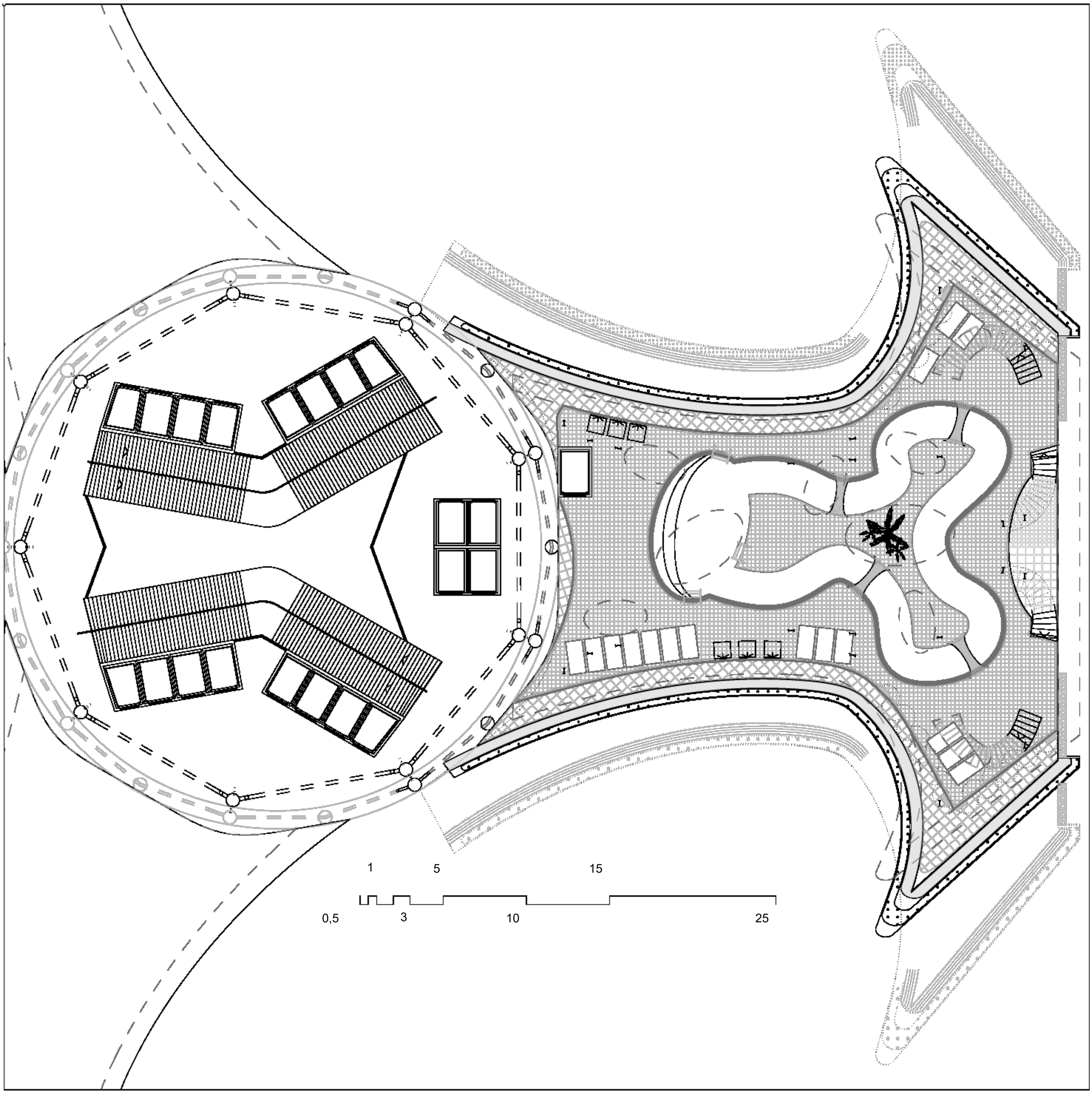

1
5
15
0,5
3
10
25

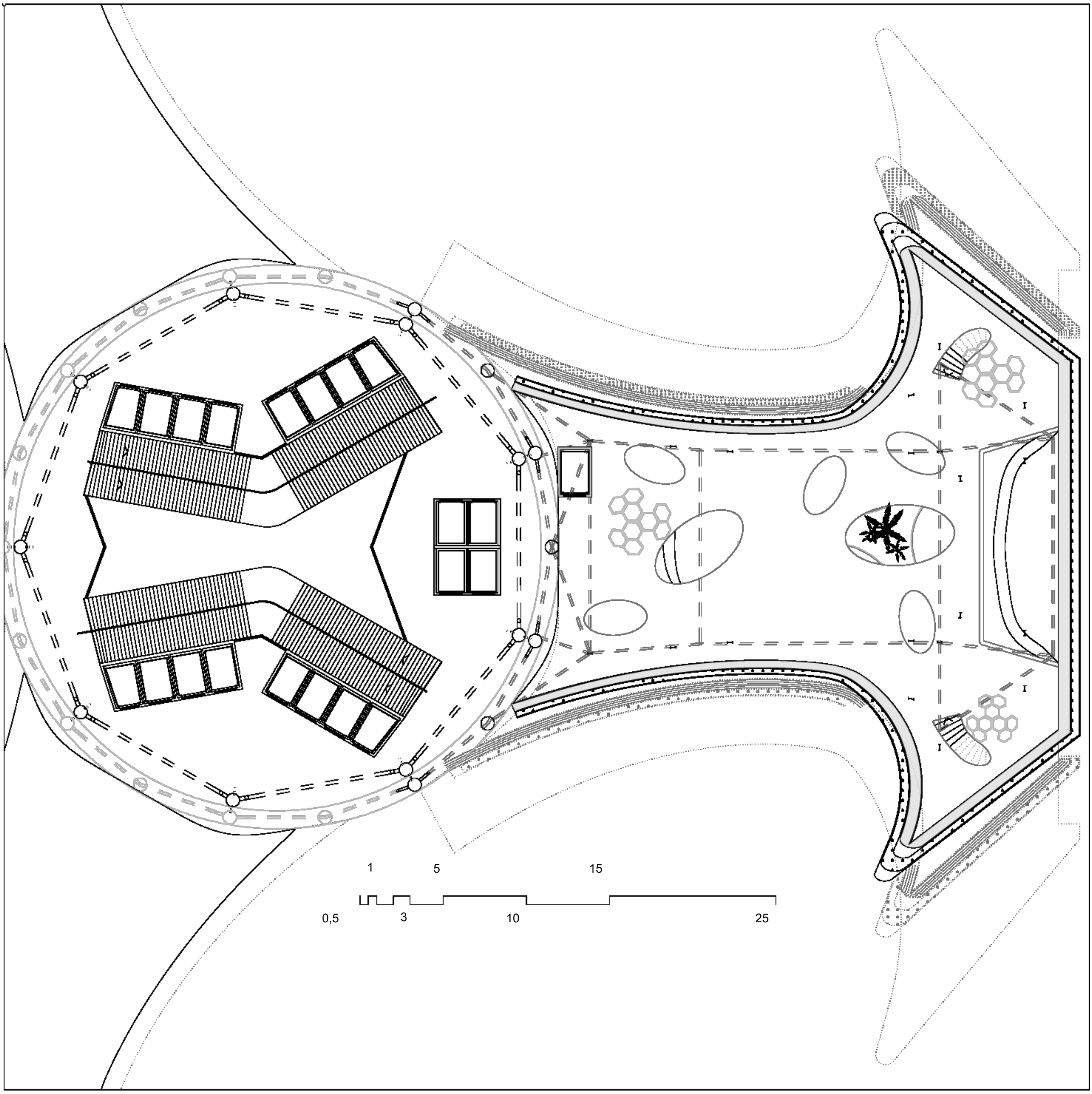
Smaler Basin - Pool Module 2



133: First Person Perspectives - Smaler Basin

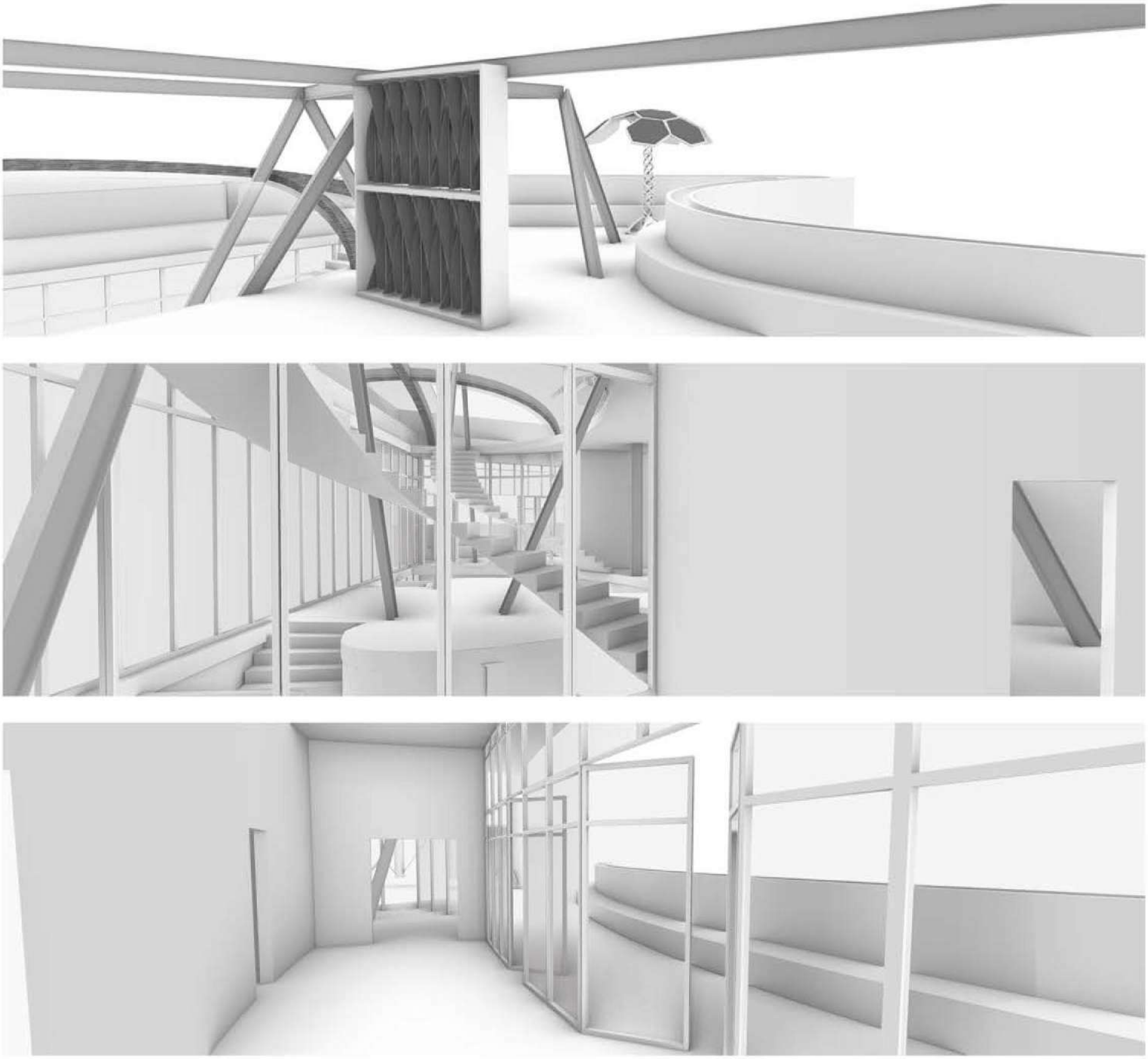

04_Grundrisse
Pool _children
1
5
15
0,5
3
10
25


1
5
15
0,5
3
10
25

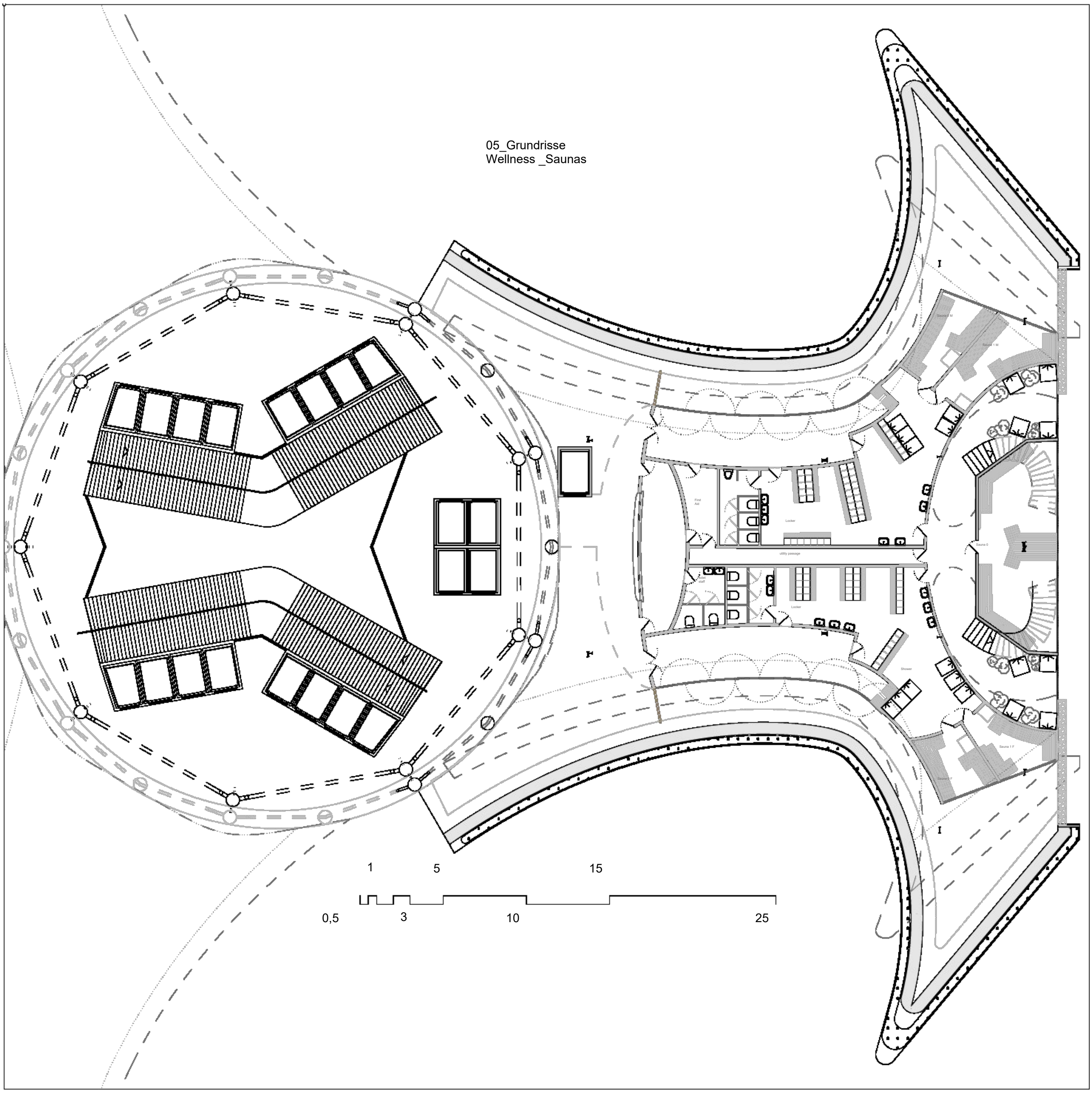


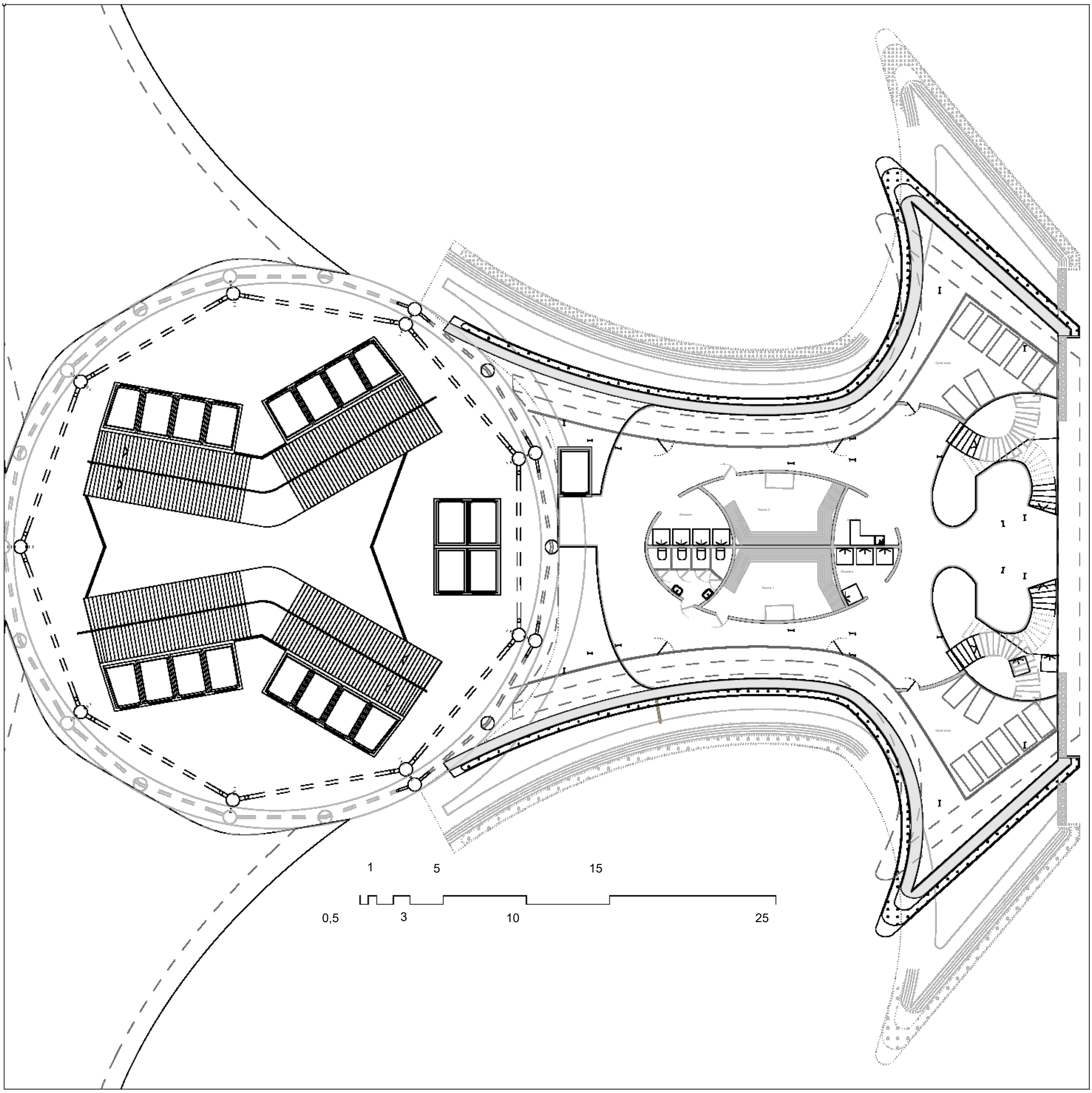
134: Floorplans - Smaler Pool

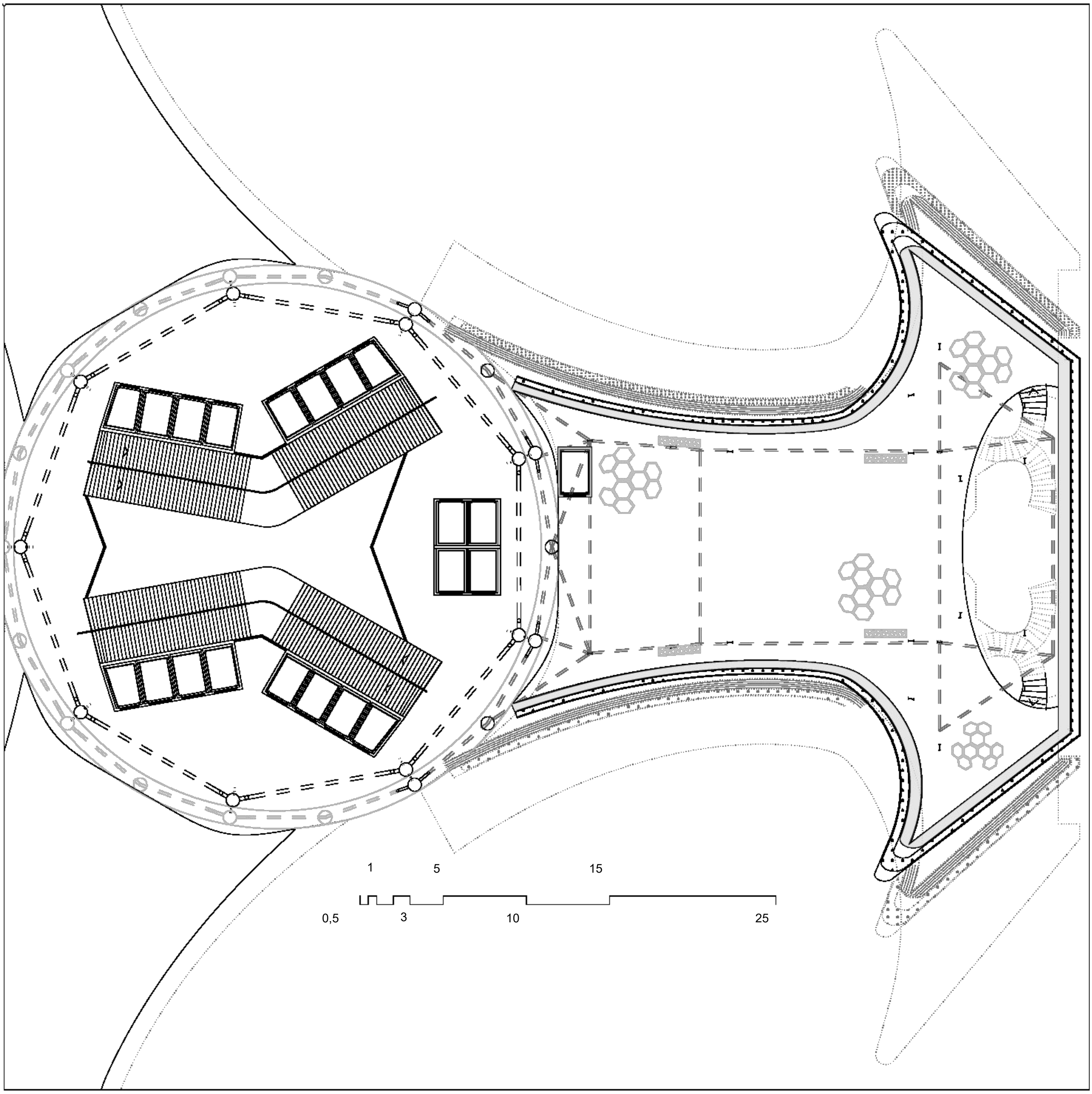
Sauna Module



135: First Person Perspectives - Saunas

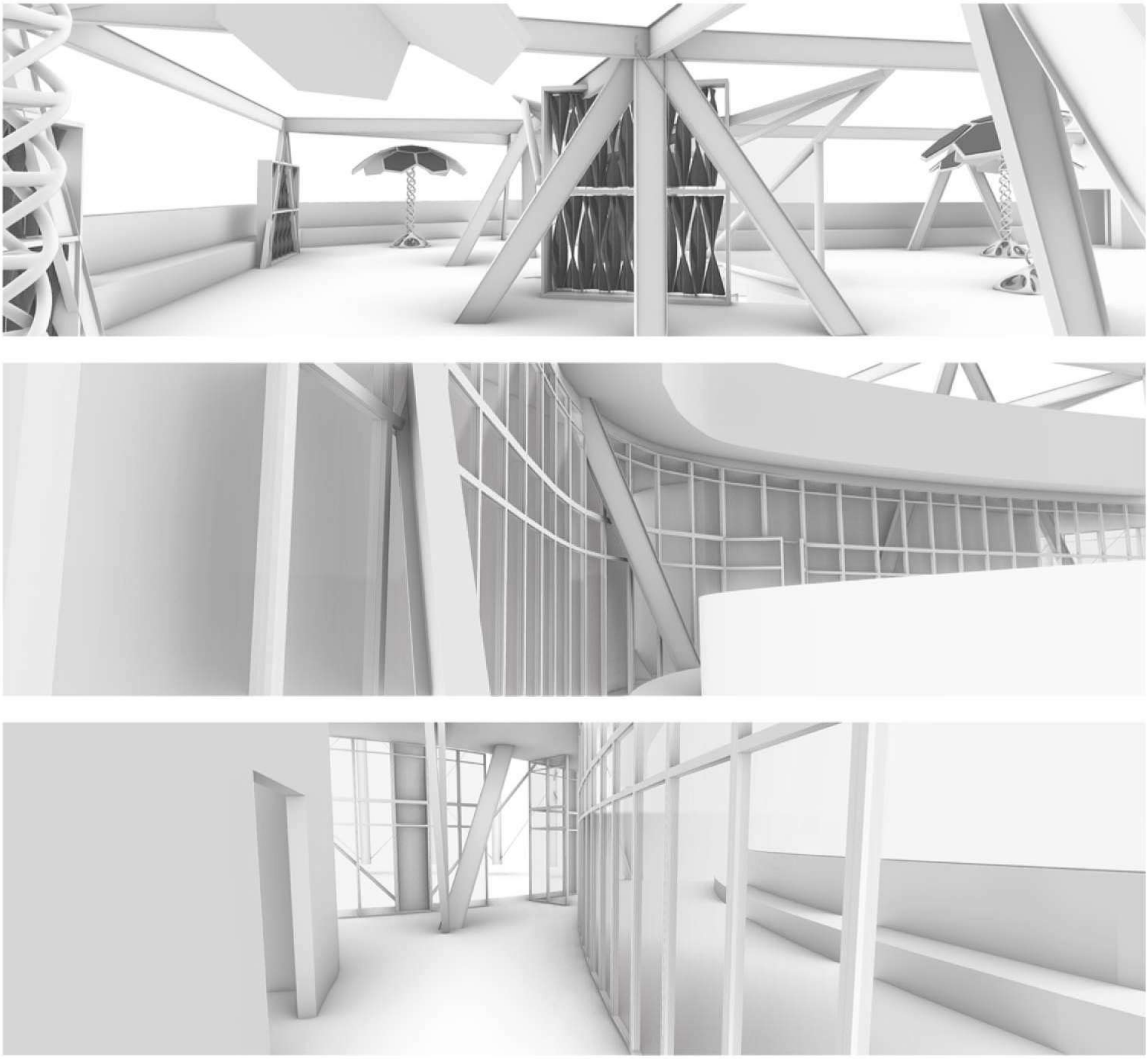

05_Grundrisse
Wellness _Saunas
1
5
15
0,5
3
10
25


1
5
15
0,5
3
10
25

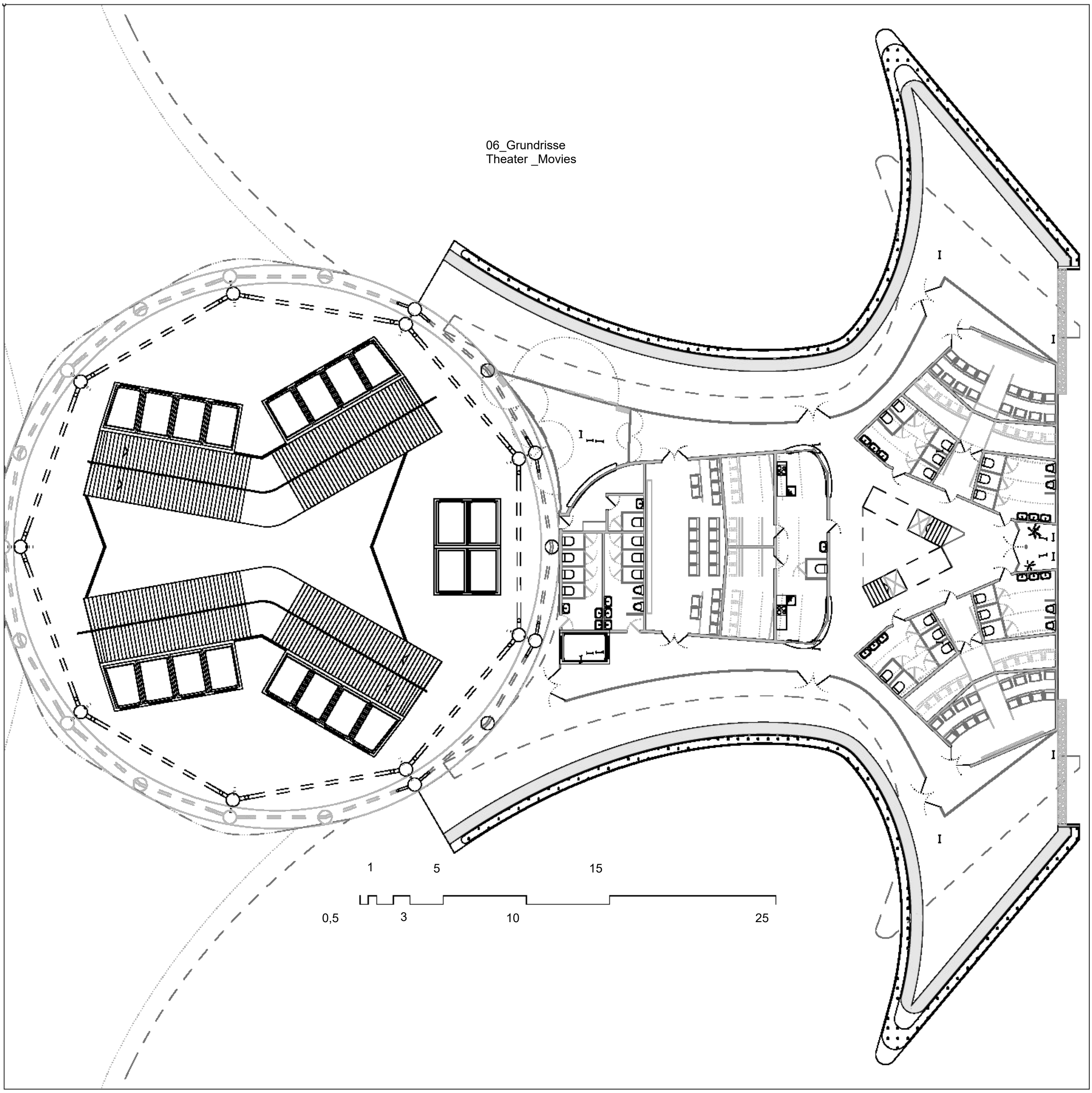


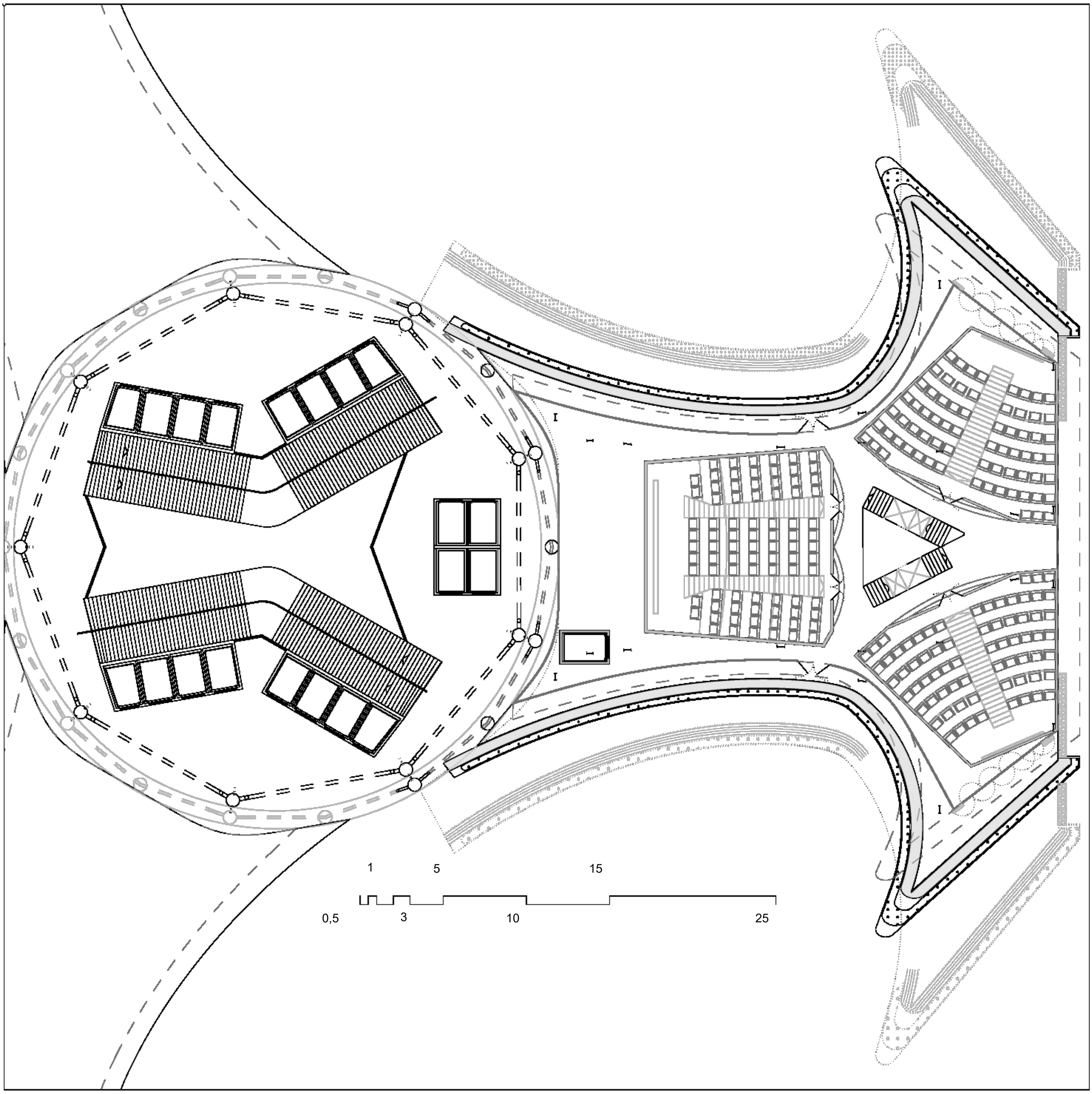
136: Floorplans - Sauna

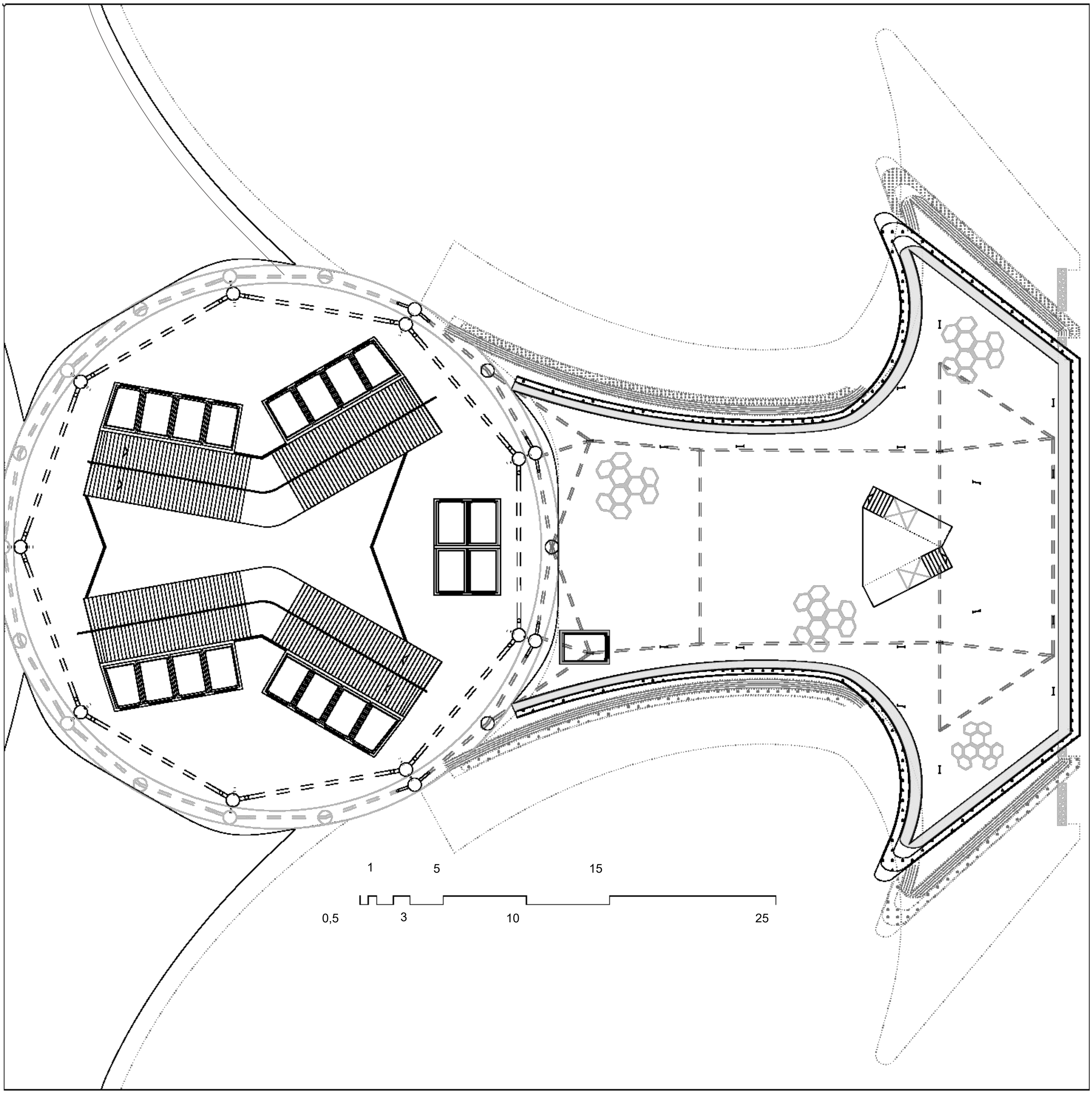
Movie Theater and Auditorium Module



137: First Person Perspectives - Theaters and Auditoriums

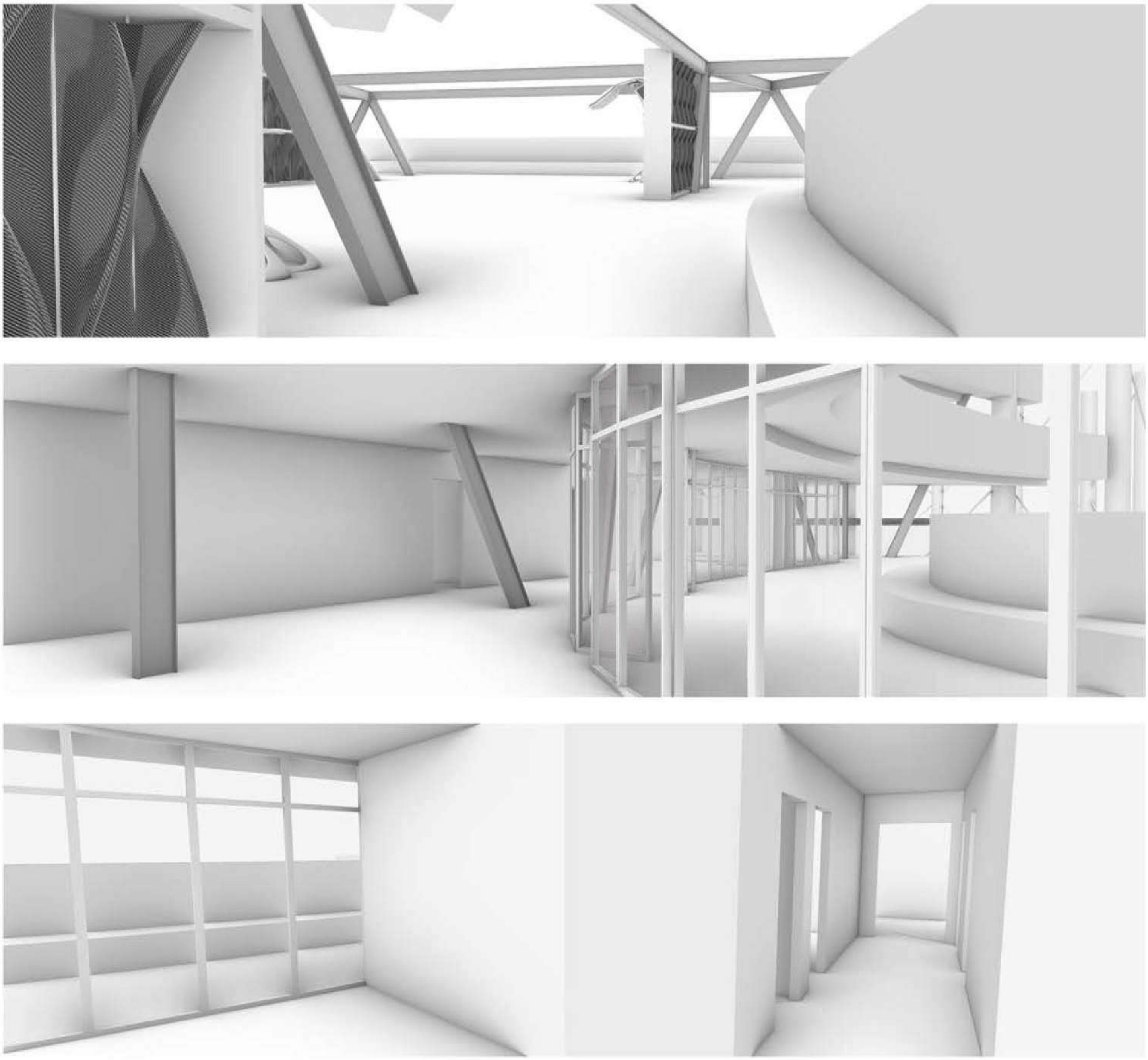

06_Grundrisse
Theater _Movies
1
5
15
0,5
3
10
25


1
5
15
0,5
3
10
25

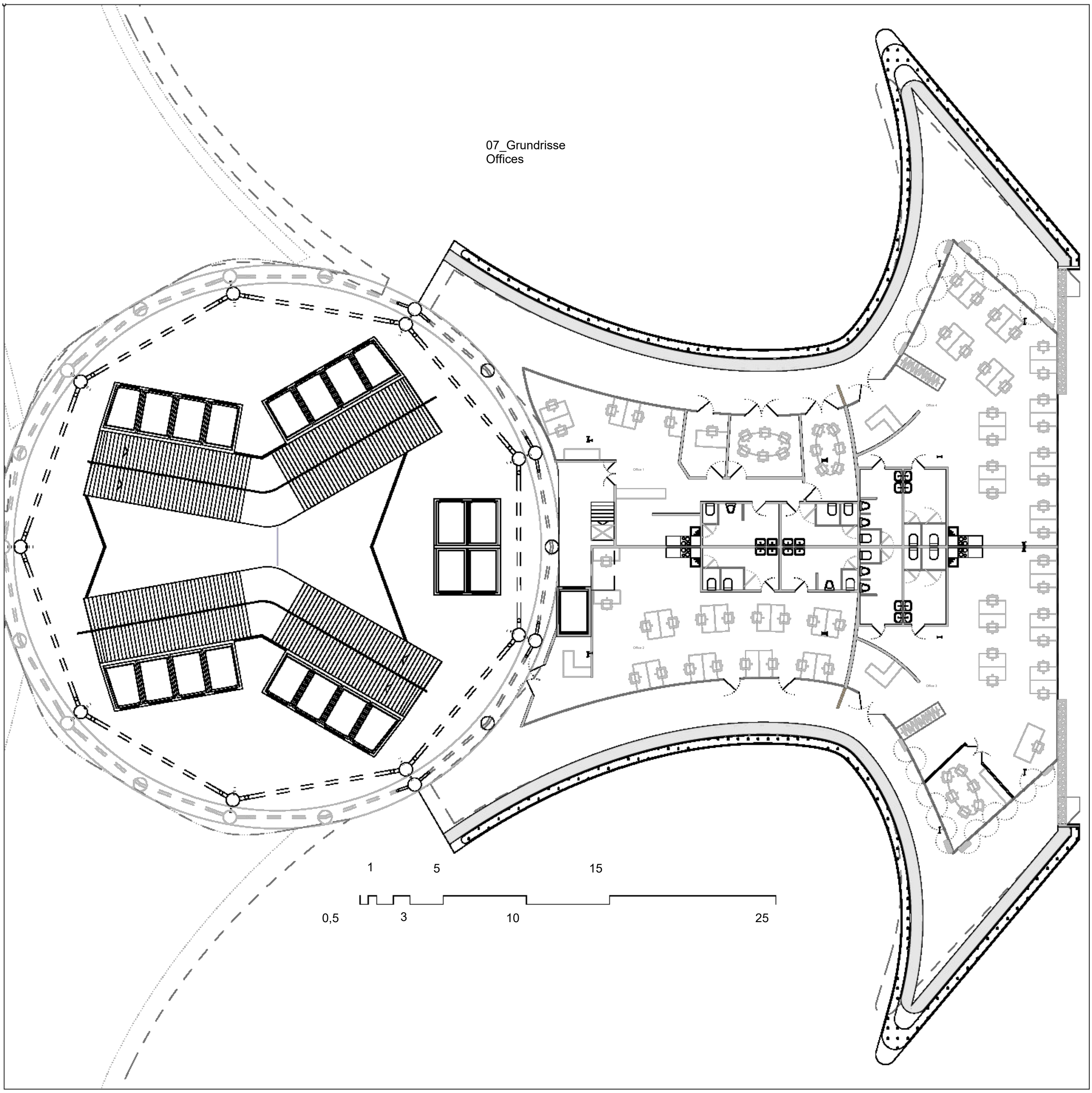


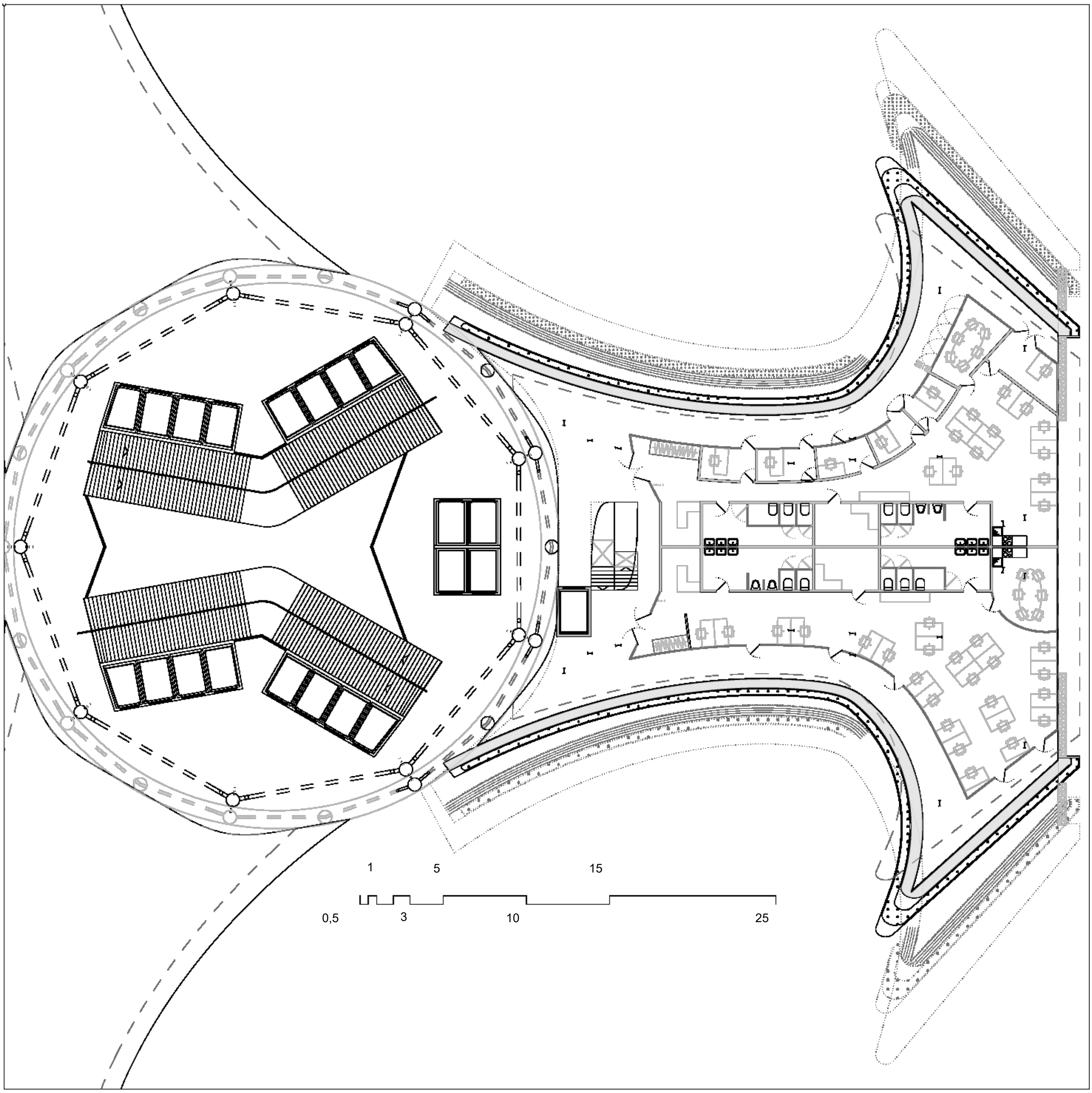
138: Floorplans - Theater and Auditoriums

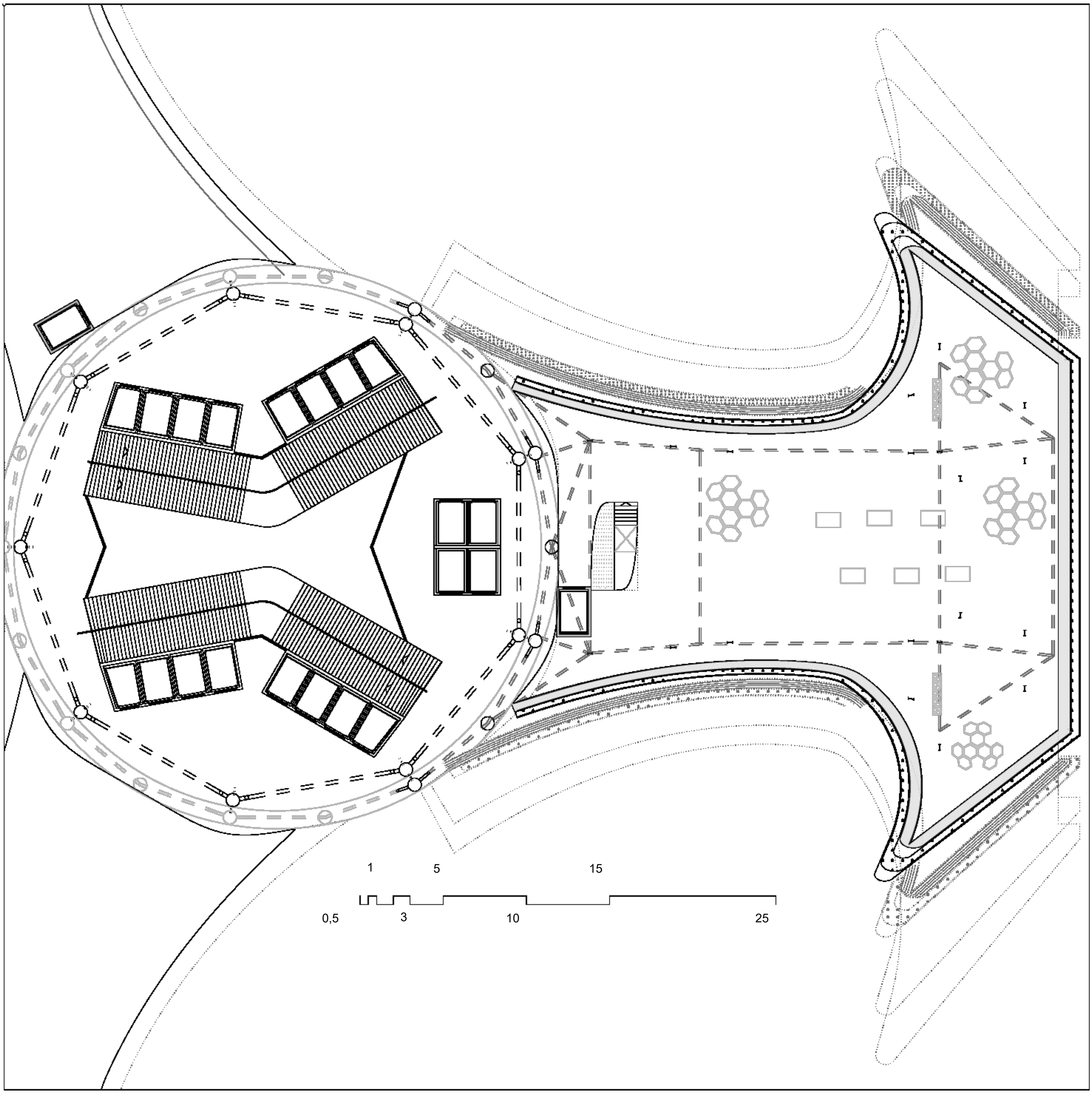
Office - Module



139: First Person Perspectives - Offices

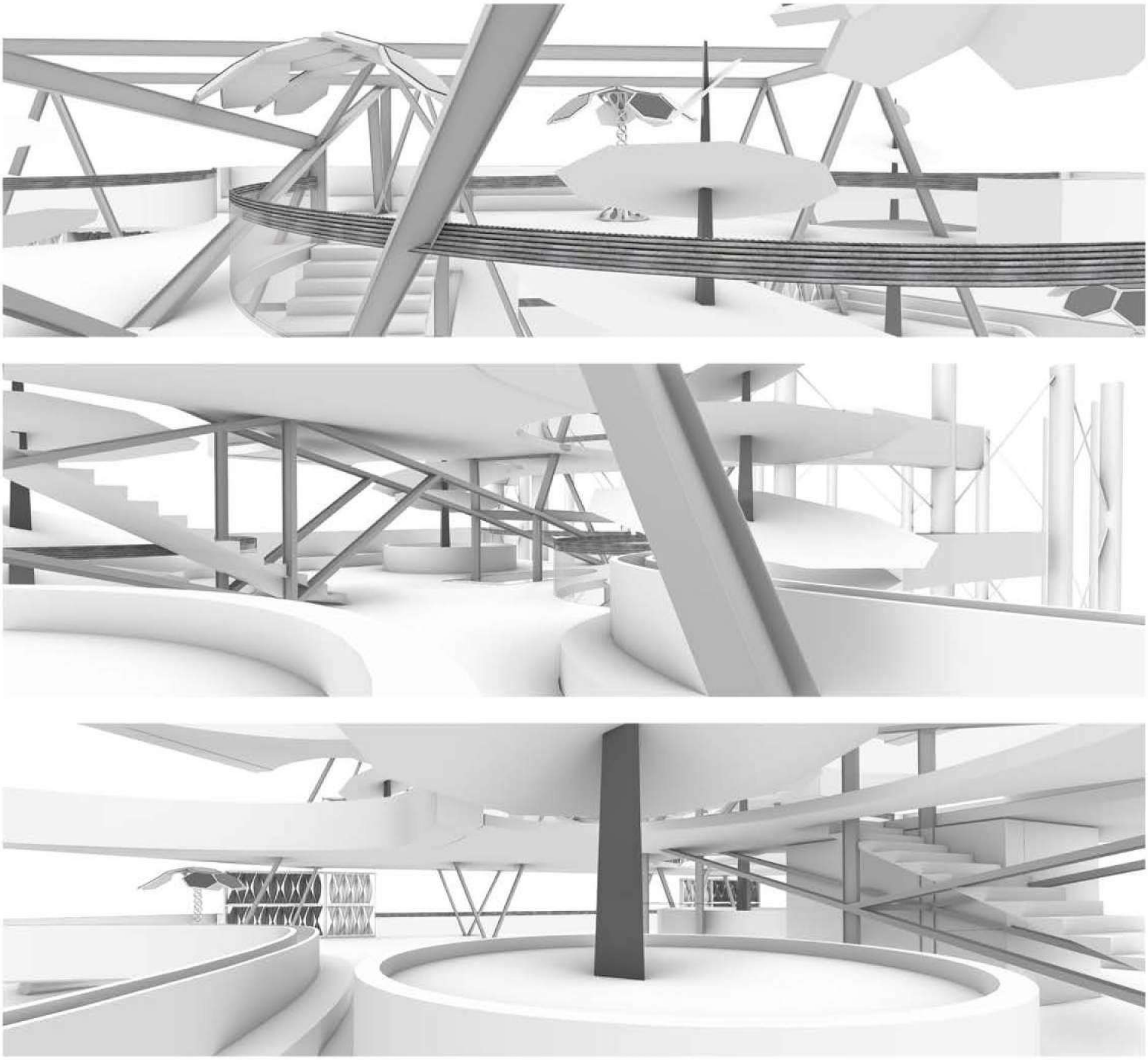

07_Grundrisse
Offices
1
5
15
0,5
3
10
25


1
5
15
0,5
3
10
25

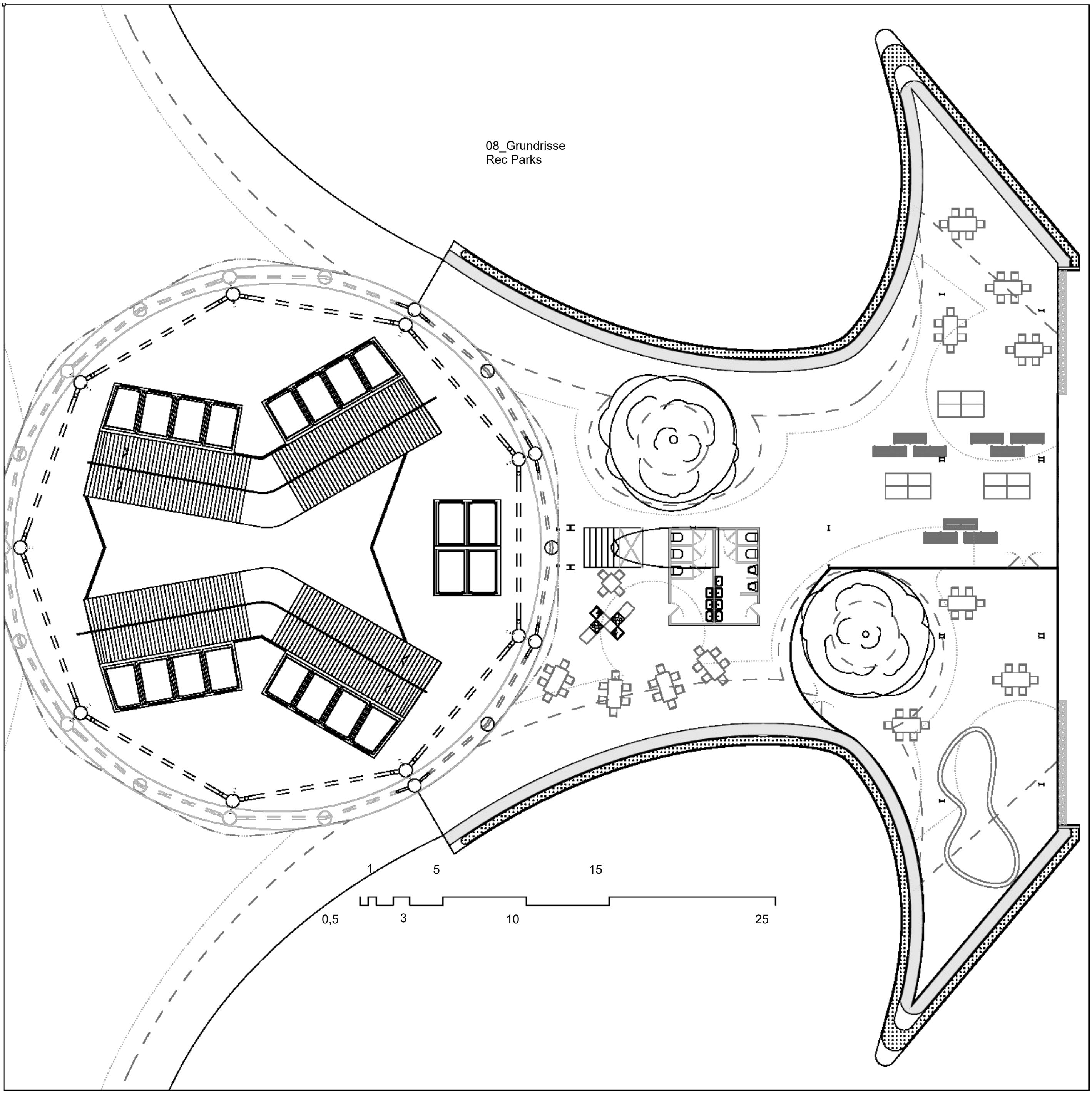


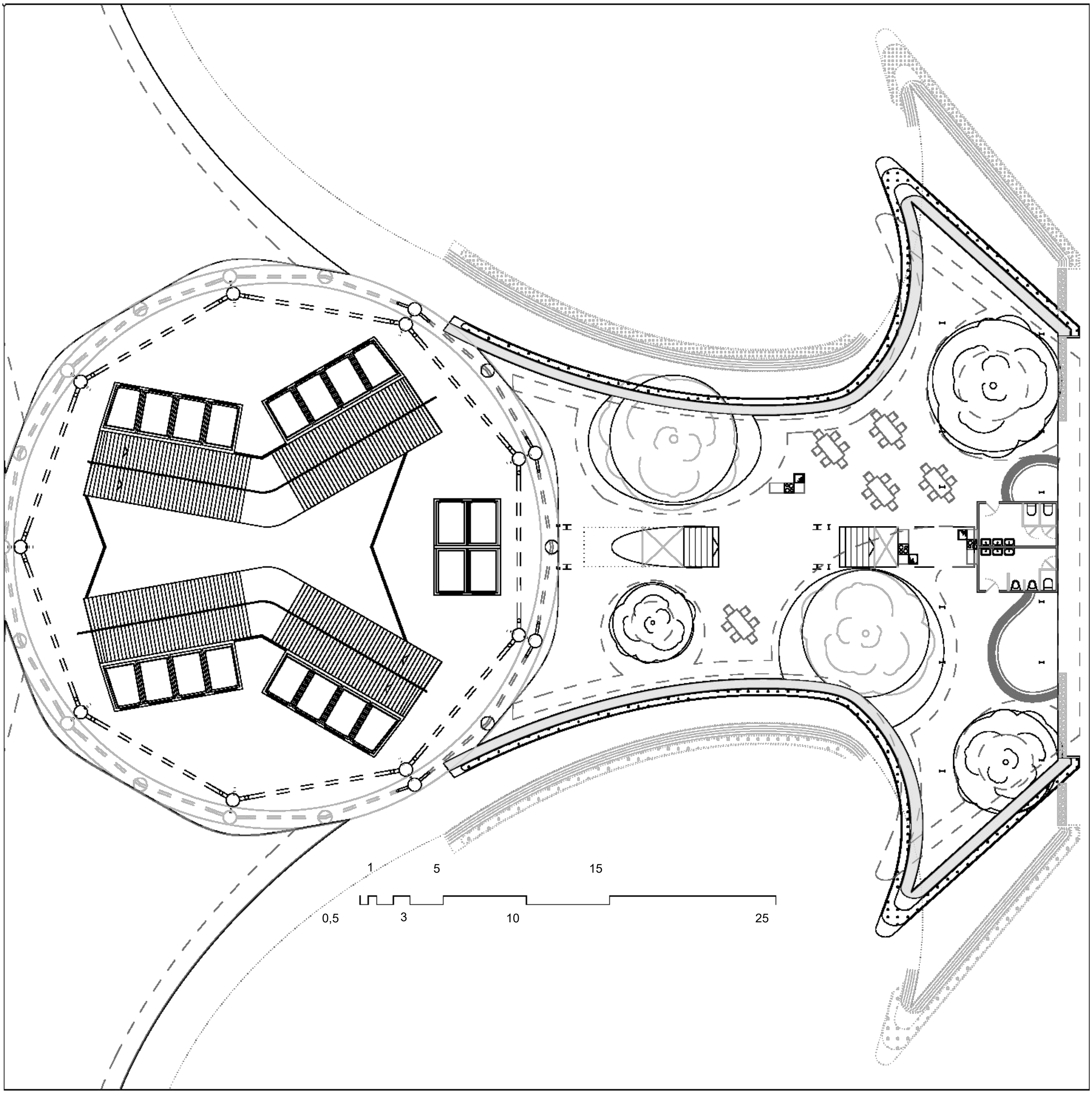
140: Floorplans - Offices

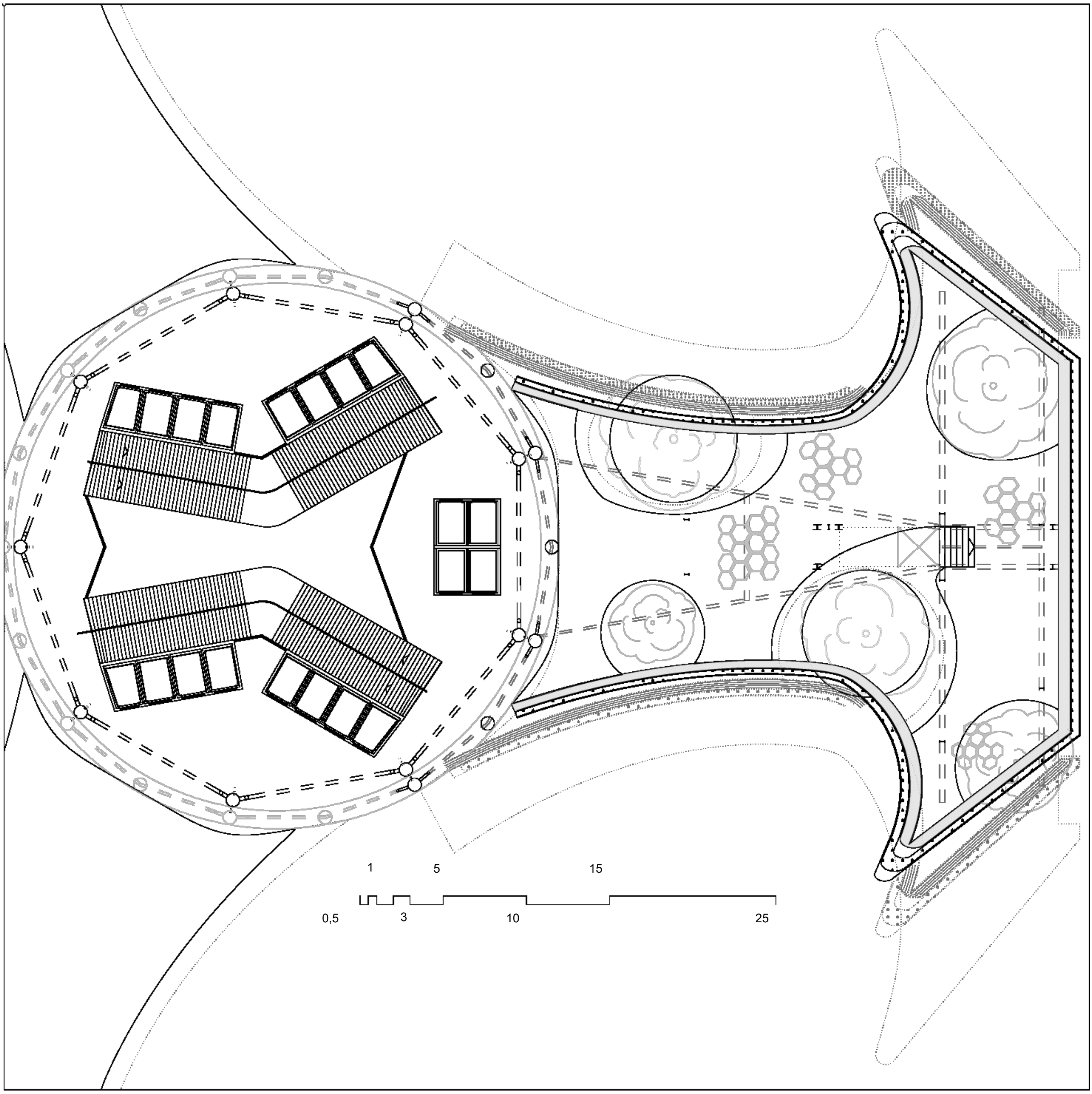
Park Module



141: First Person Perspectives - Parks

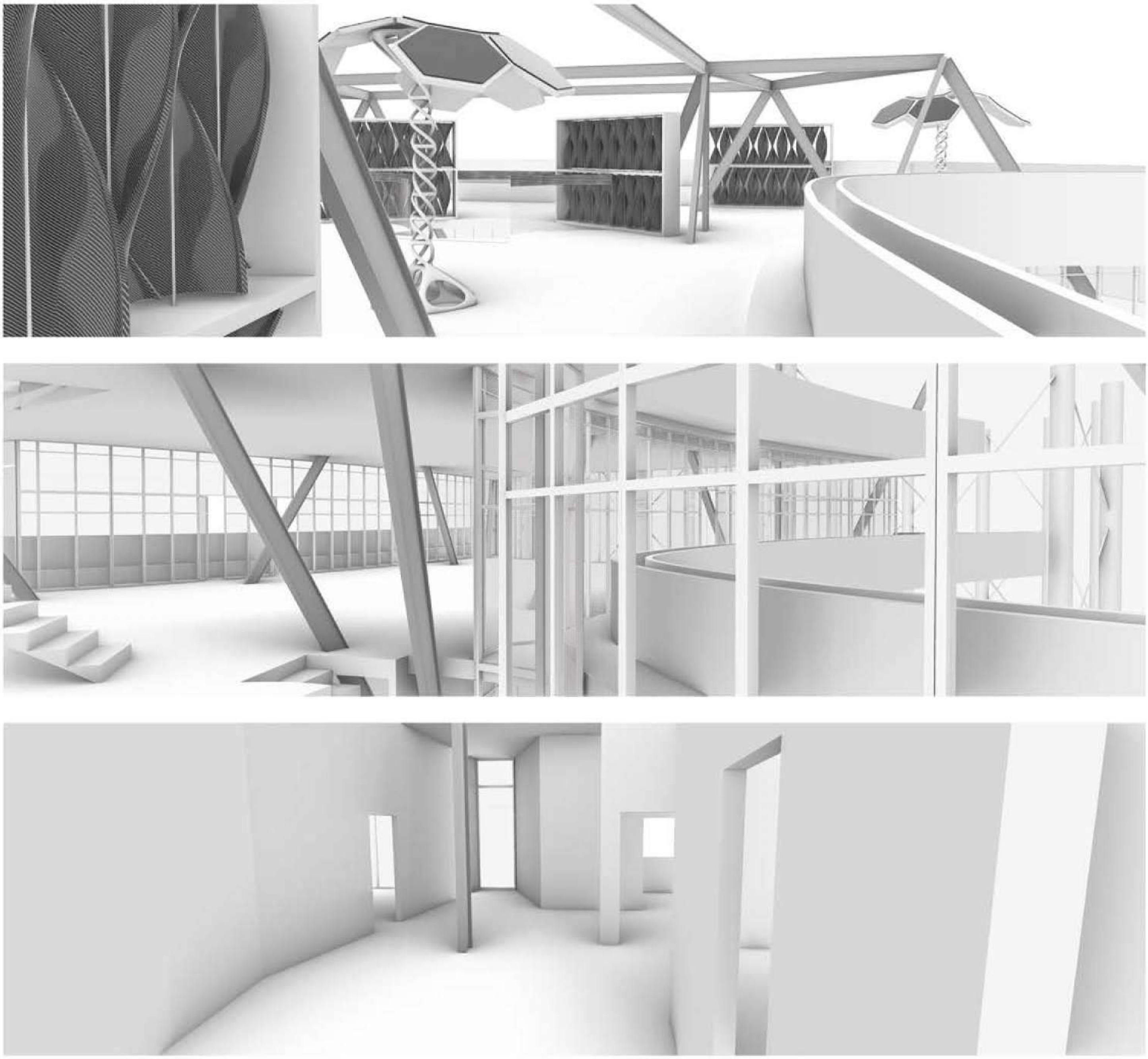

08_Grundrisse
Rec Parks
1
5
15
0,5
3
10
25


1
5
15
0,5
3
10
25

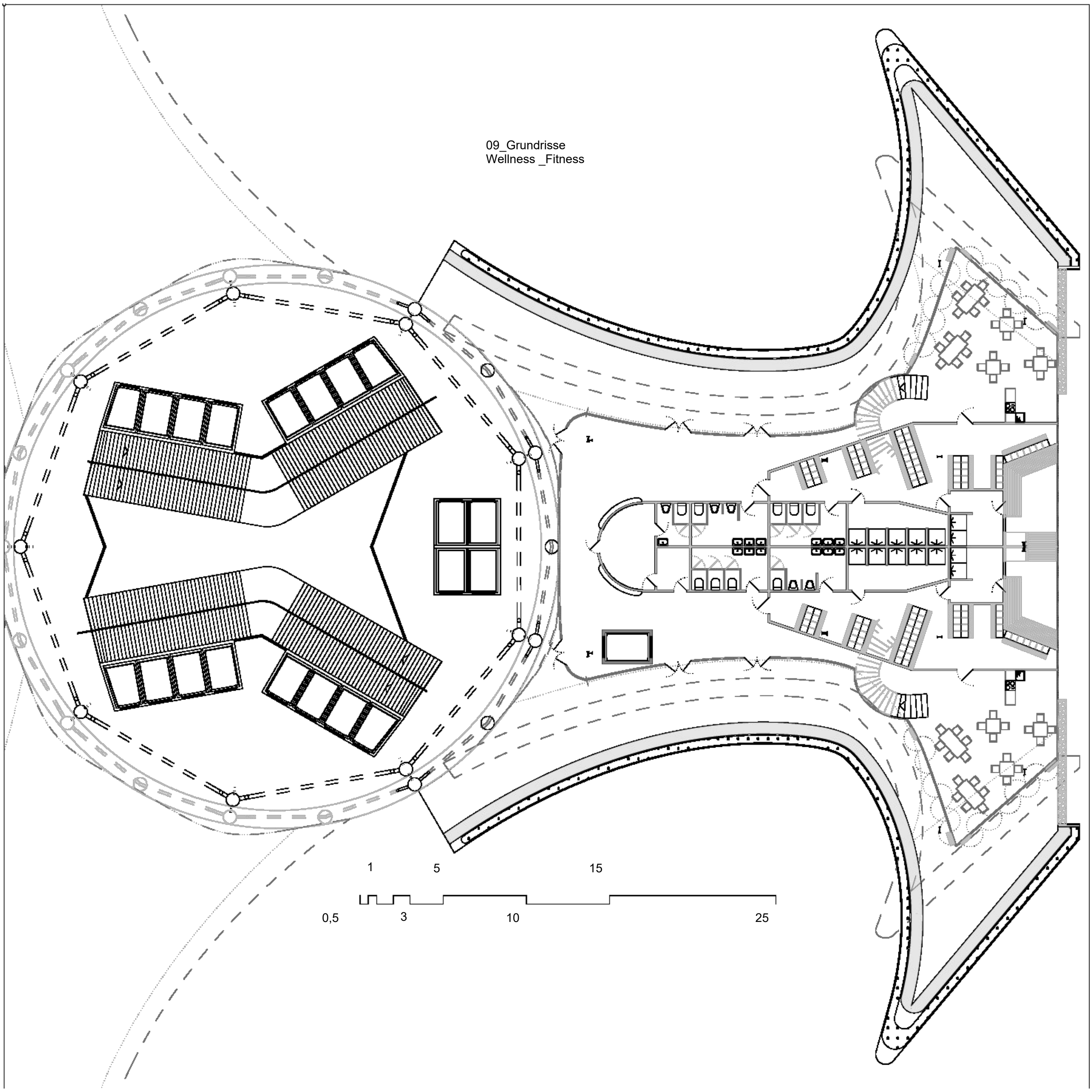


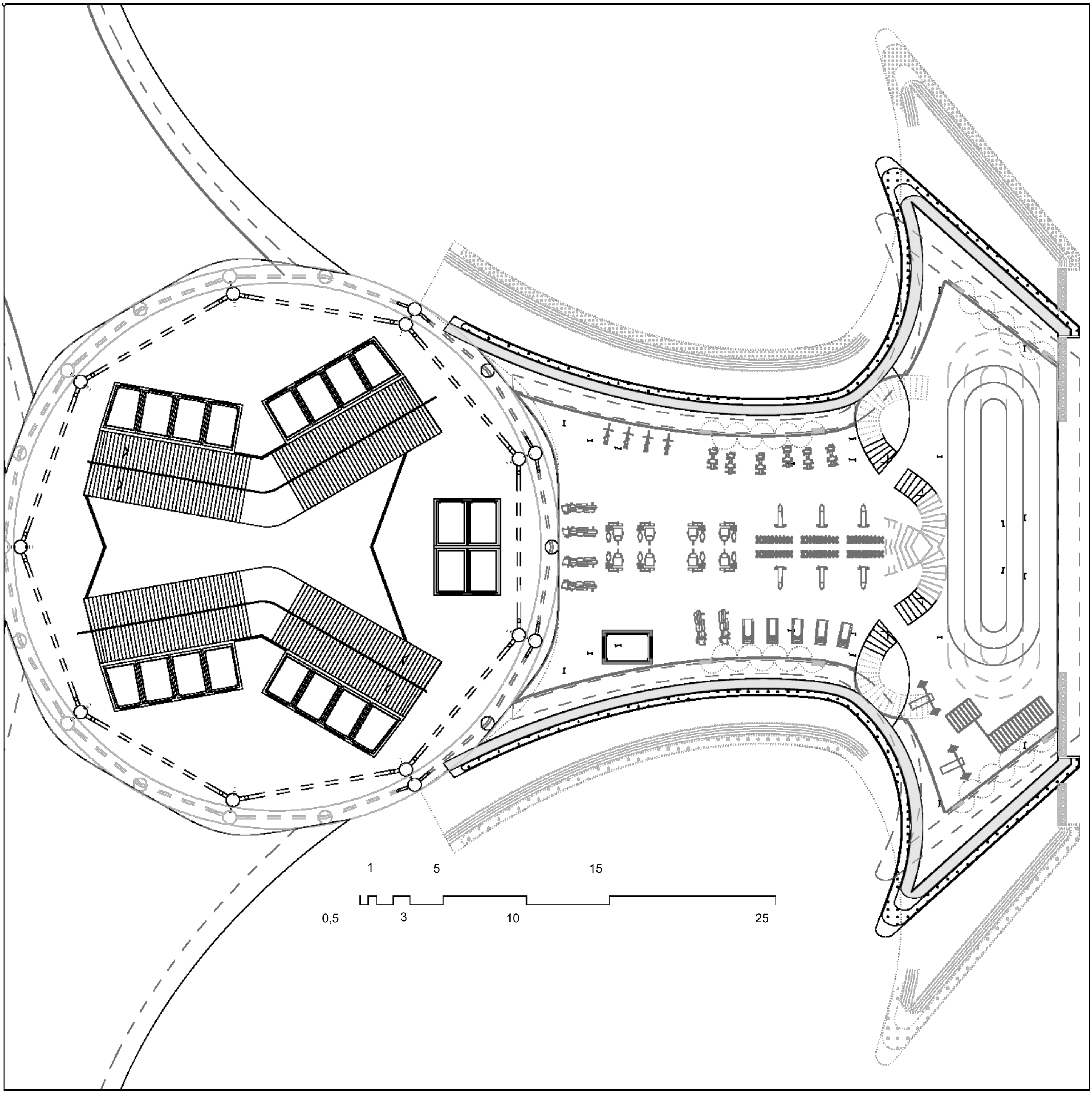
142: Floorplans - Park

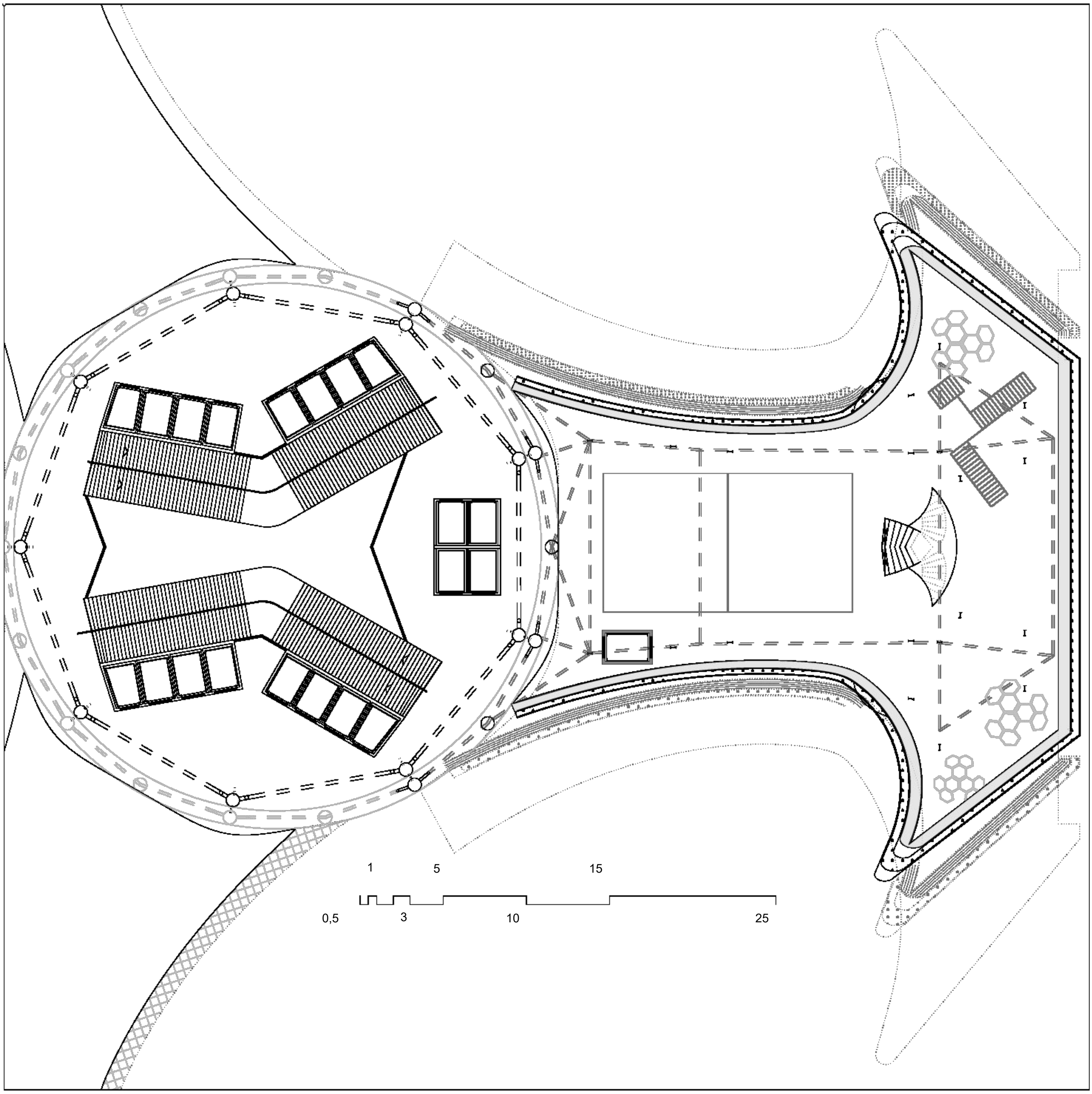
Sportsfacilities



143: First Person Perspectives - Sports


09_Grundrisse
Wellness _Fitness
1
5
15
0,5
3
10
25


1
5
15
0,5
3
10
25

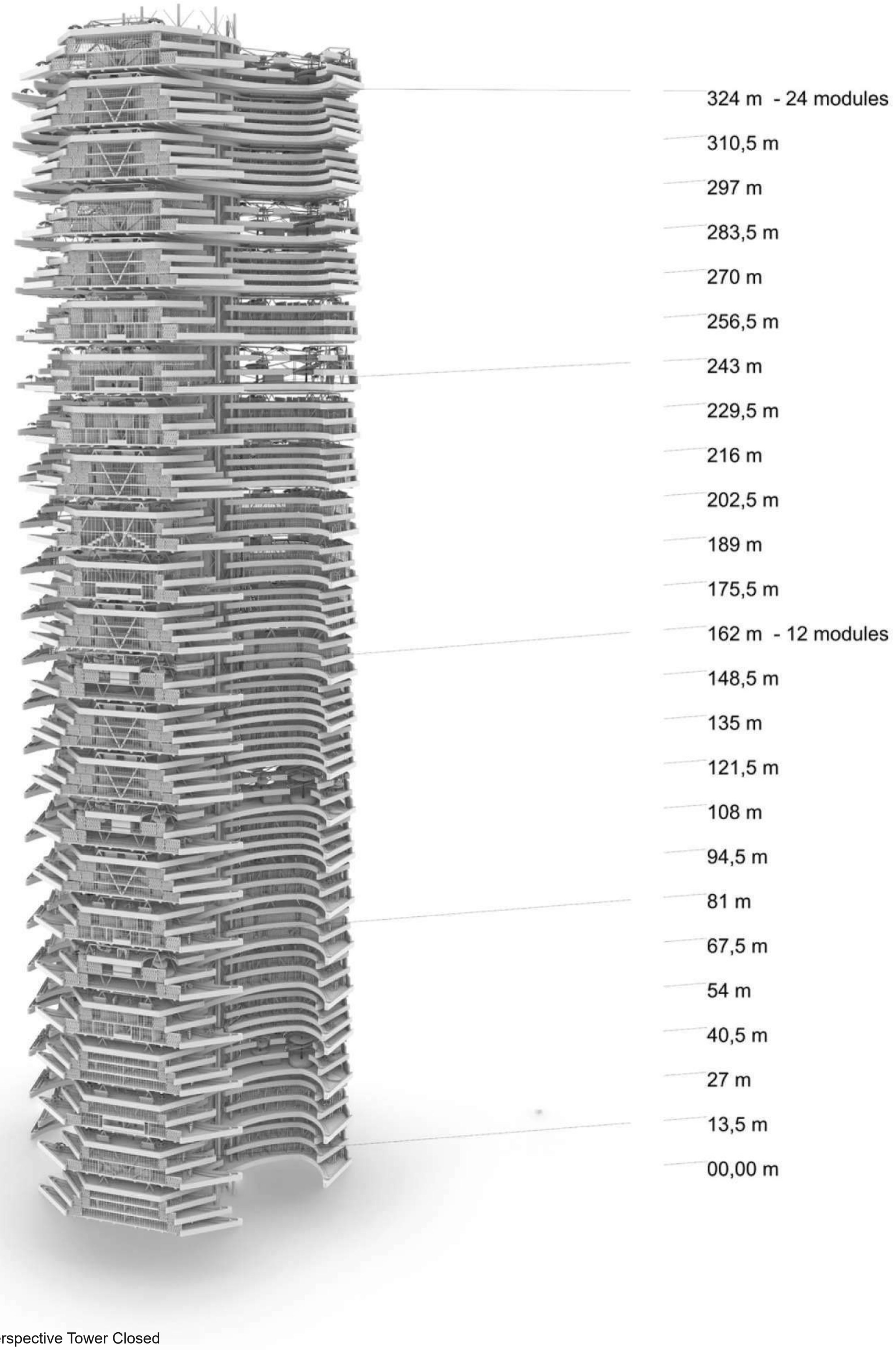


144: Floorplans - Sportsfacilities

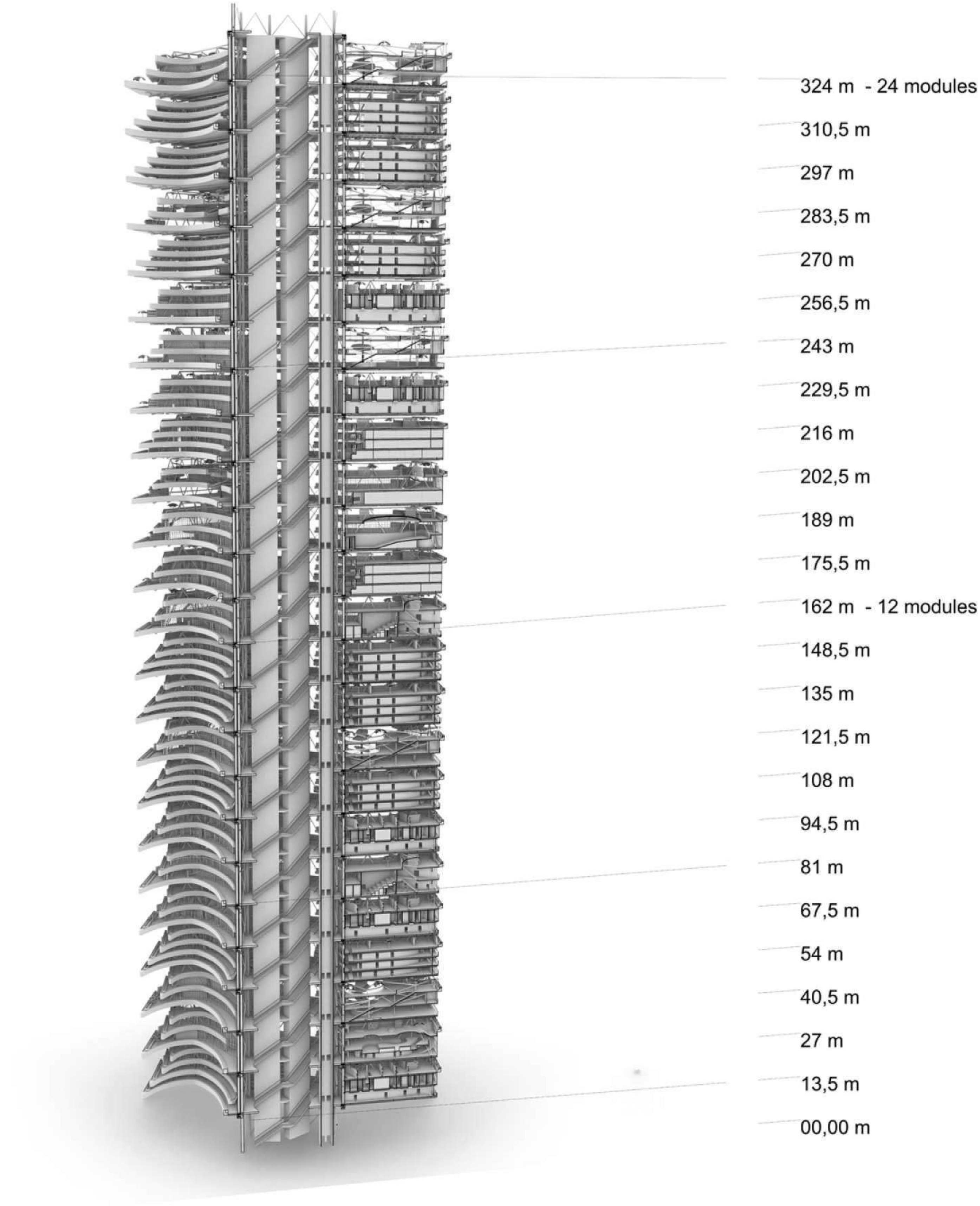
5.3 Elevations and Sections

Closed Tower

145: Birdseye Perspective Tower Closed on Possible Site - 1030 Vienna



146: Elevation Perspective Tower Closed



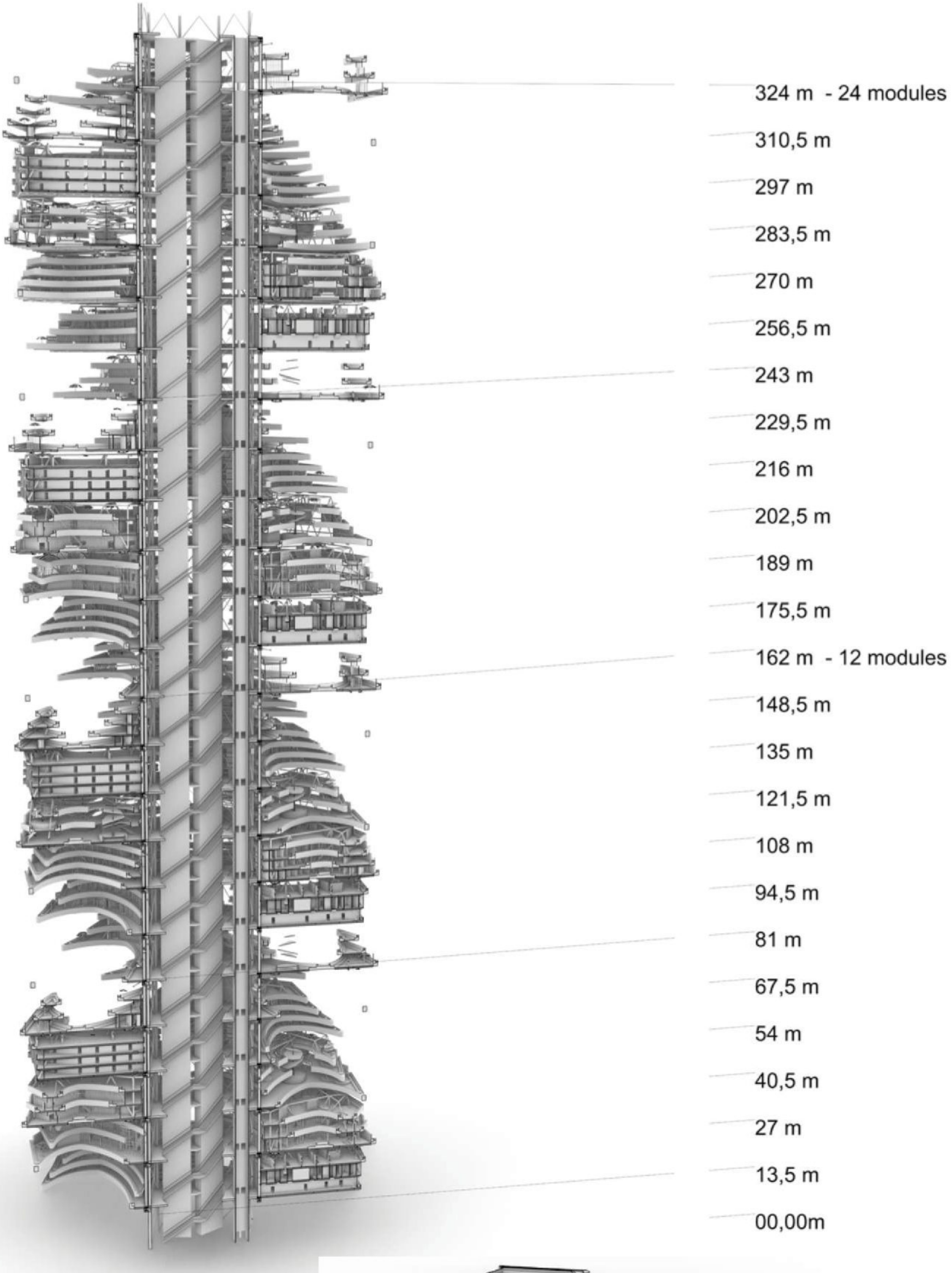
147: Section Perspective Tower Closed

5.3 Elevations and Sections

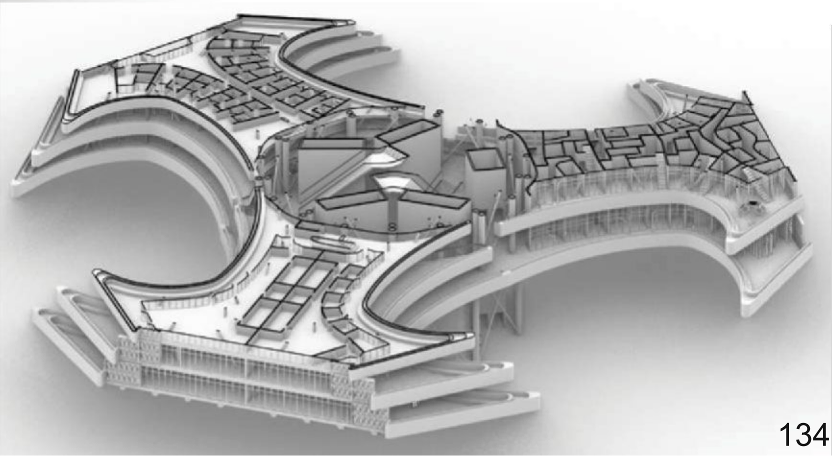
Open Tower


148: Birdseye Perspective Open Closed on Possible Site - 1030 Vienna

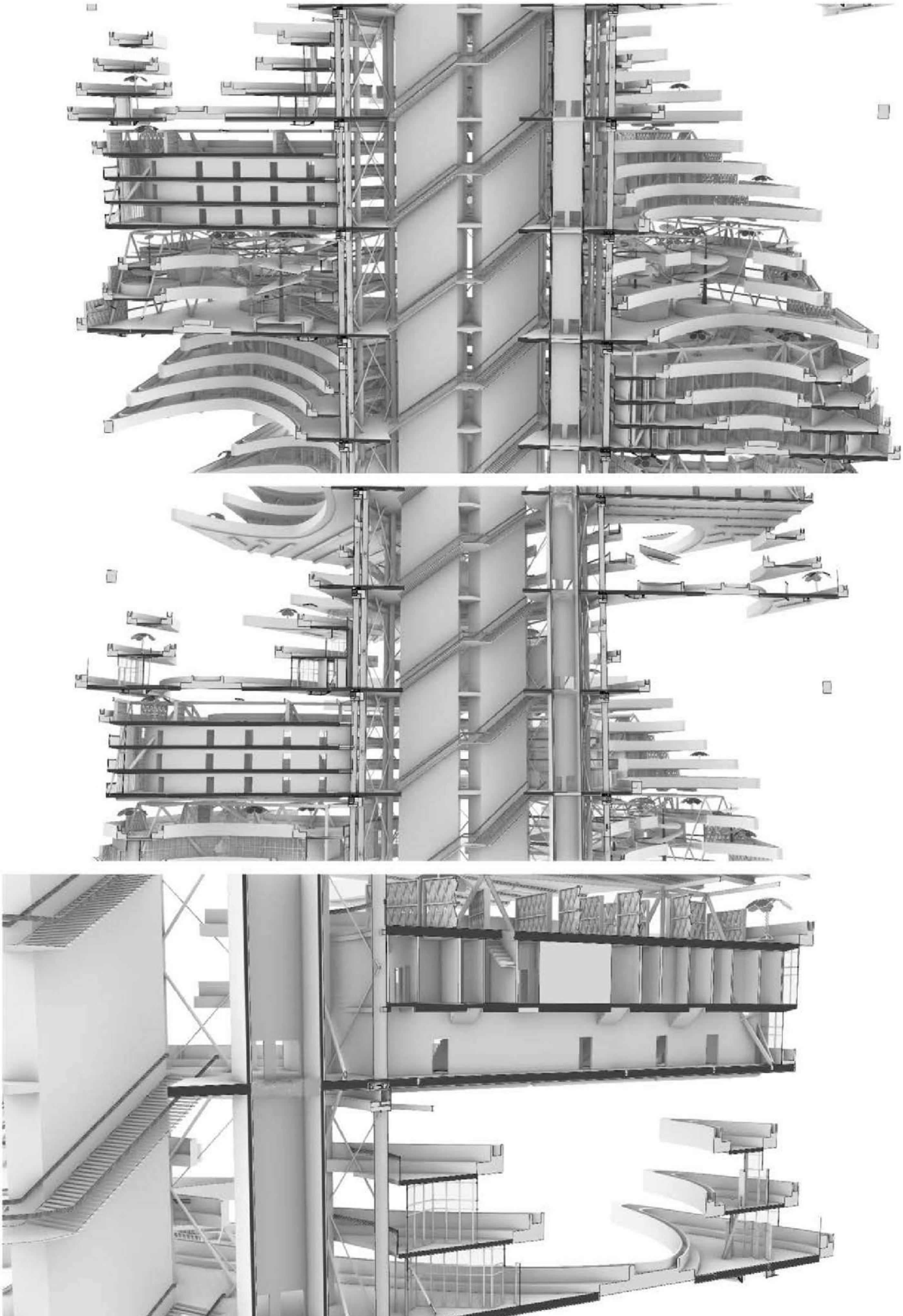
149: Elevation Perspective Tower Open



150: Section Perspective Tower Open

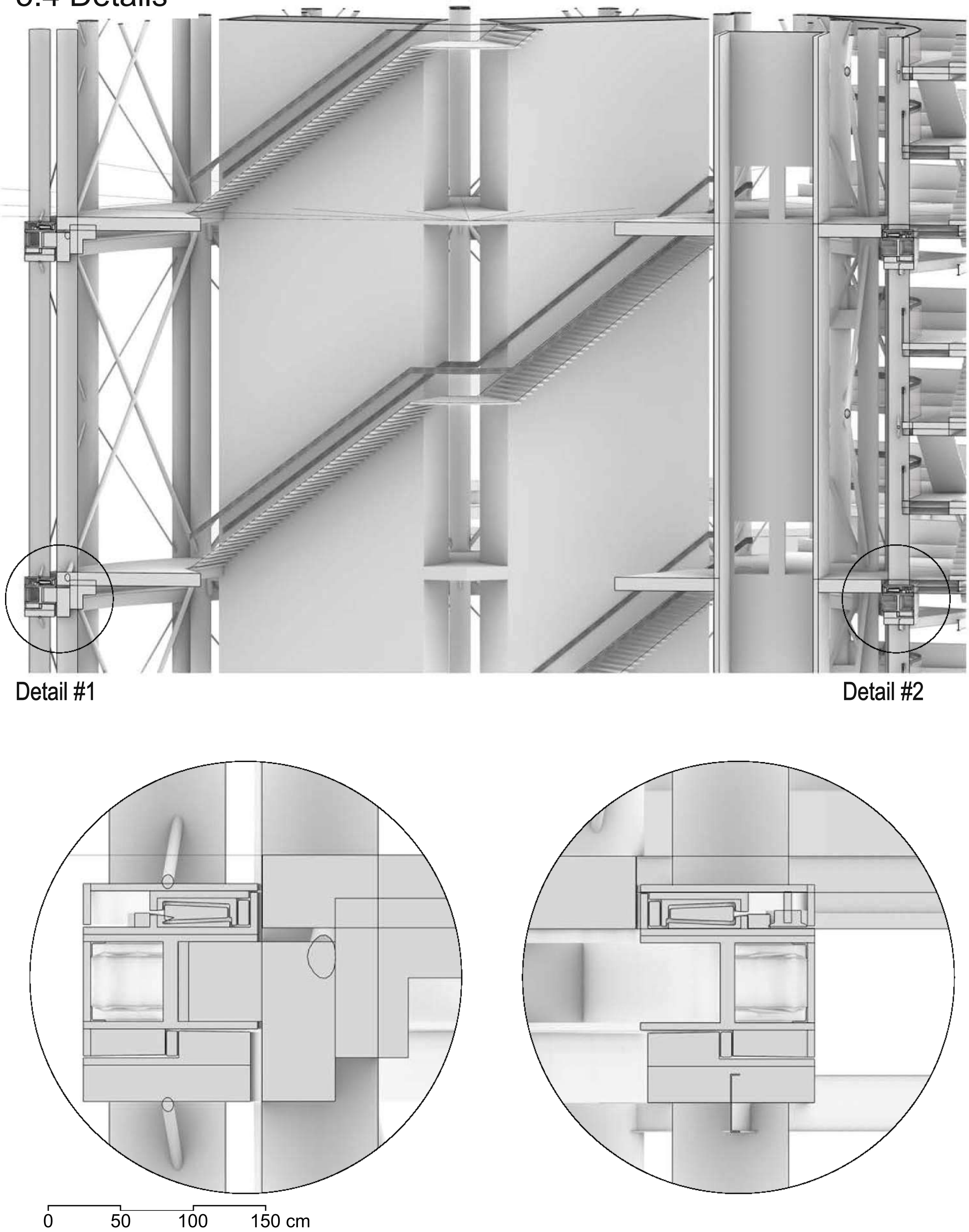


151: Sectionfloorplan Perspective first Tower Module

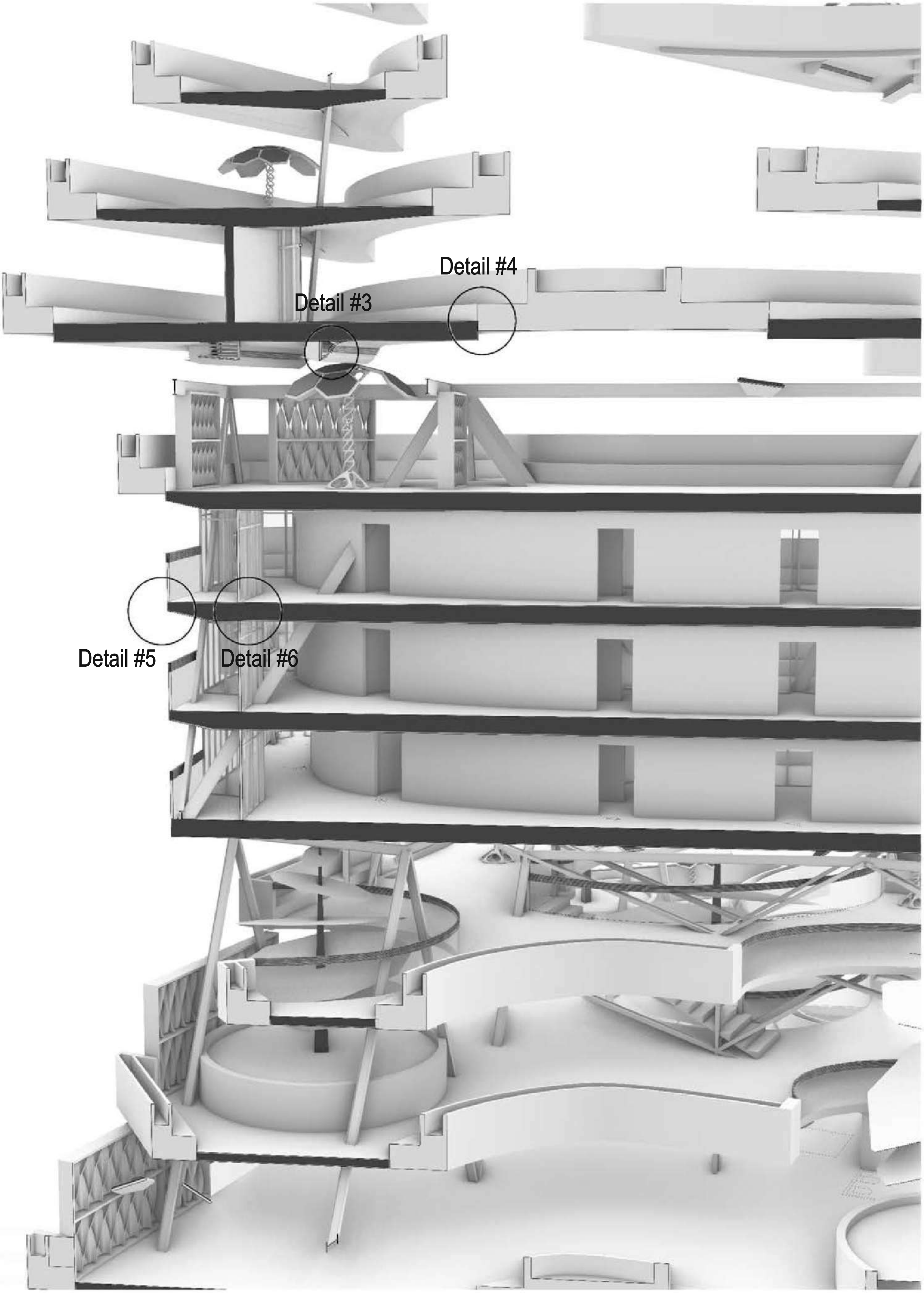


152: Closer Section Perspective Tower Open

5.4 Details

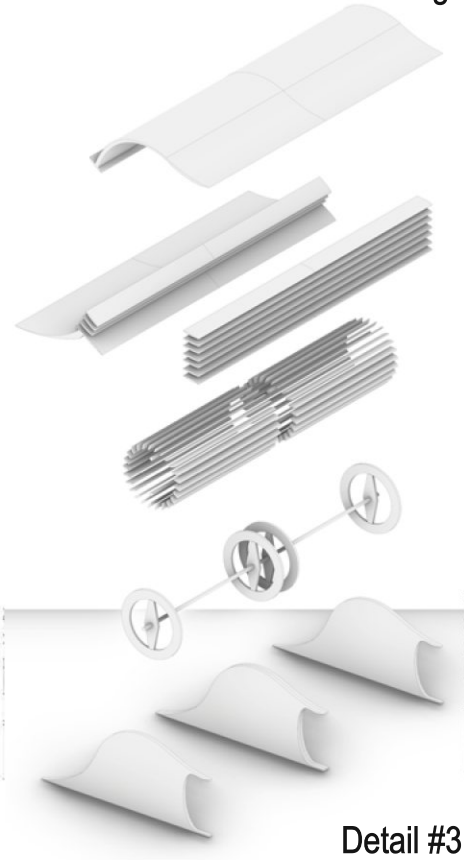


153: Detailed Section Perspective Inner Core and Bearing

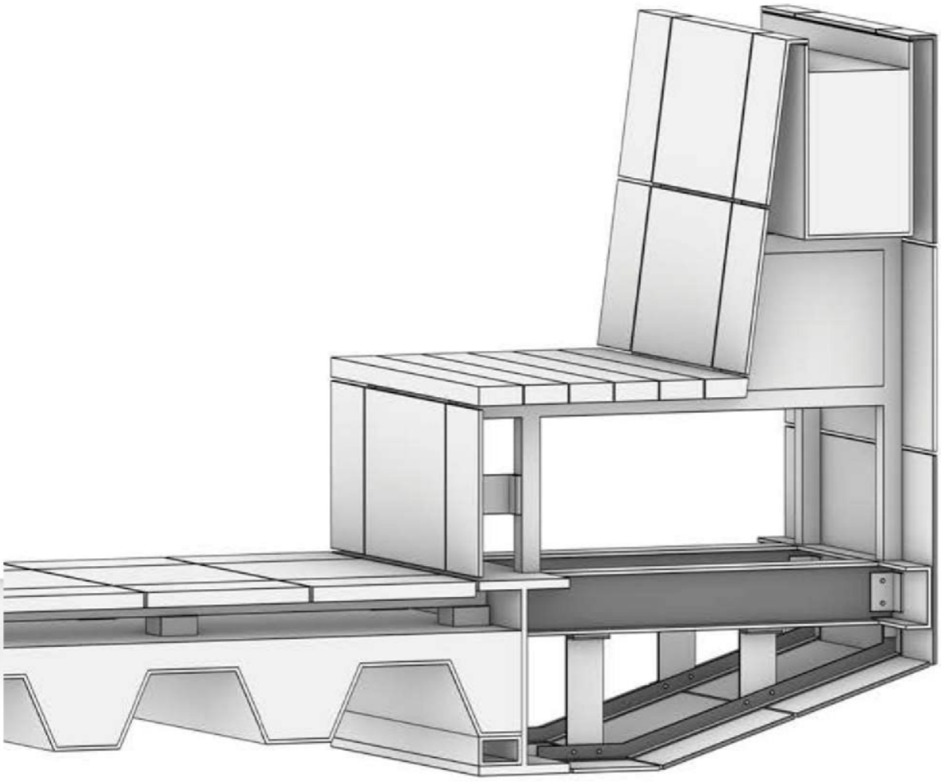


154: Detailed Section Perspective Modules

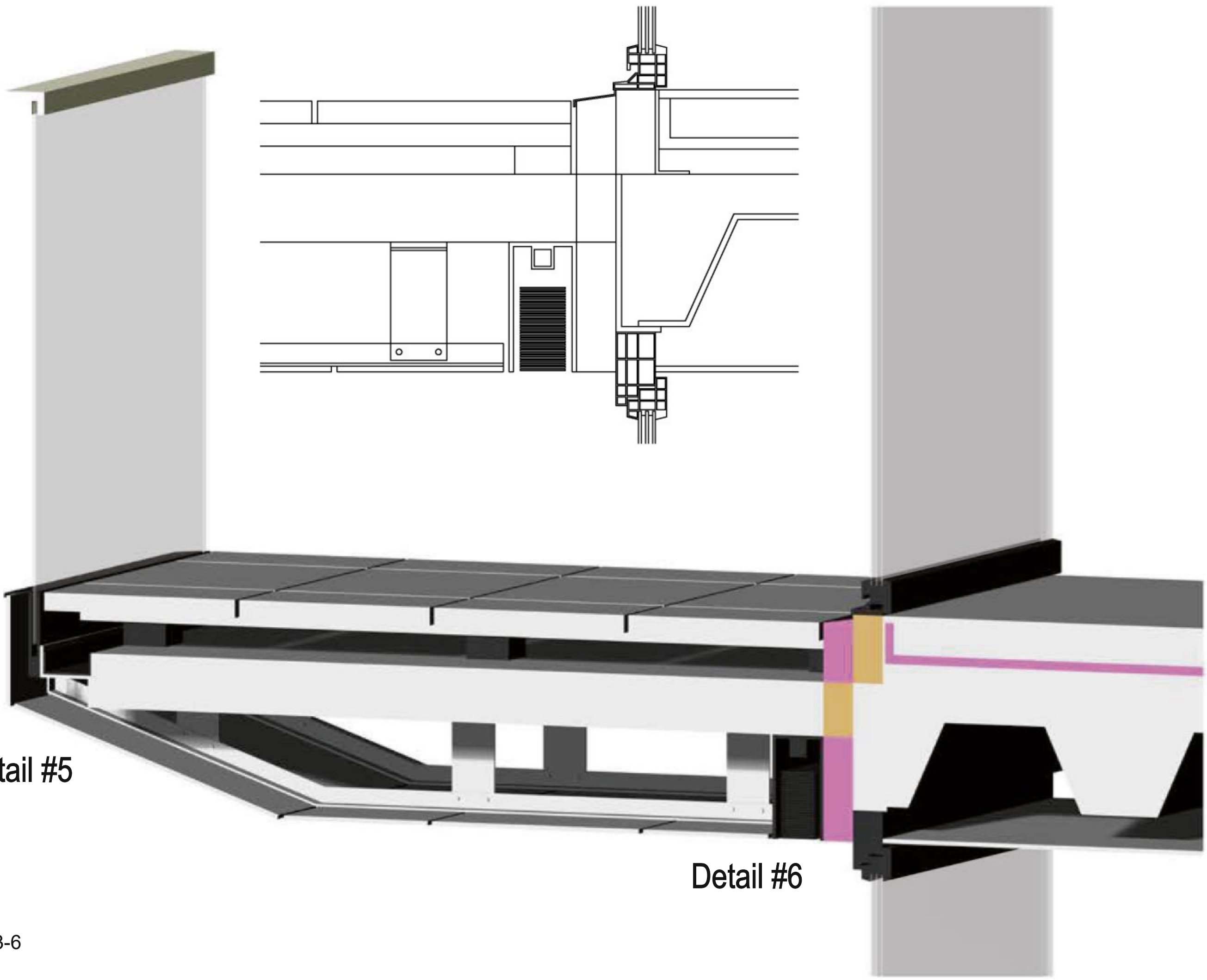
Detail #3 Ridge blade windturbine or similar product mounted to the lowest ceiling of all modules



Detail #3



Detail #4

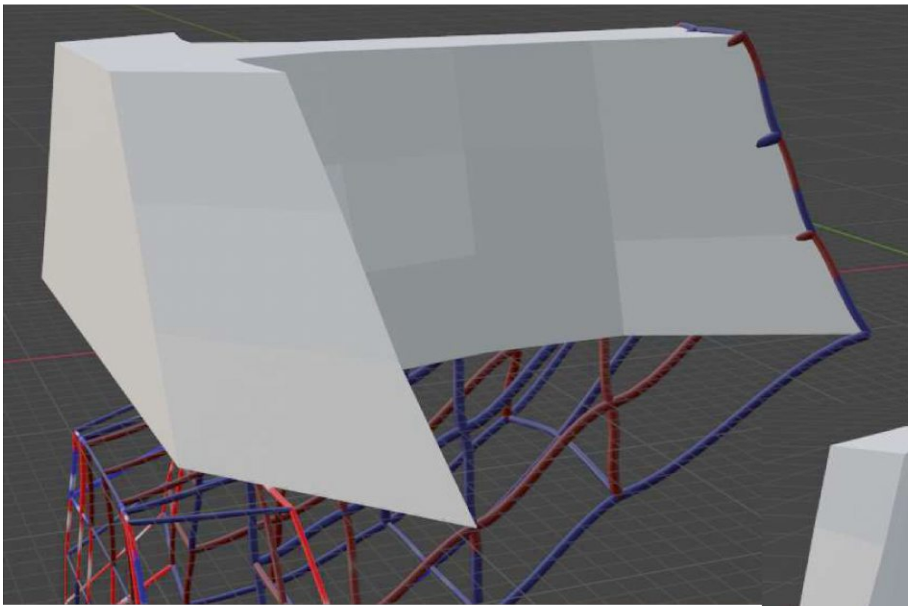


155: Detail 3-6

6 Evalutation

6.1 Space Frame Structure Evaluated in Phaenotyp

Single Frame Load Analysis - simple Rectangle frame

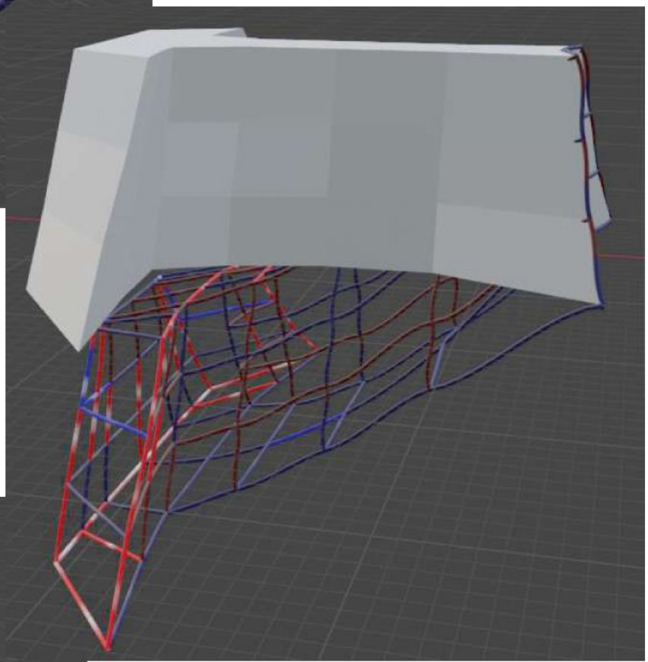


Phaenotyp Blender
FEM-analysis
Single Frame analysis

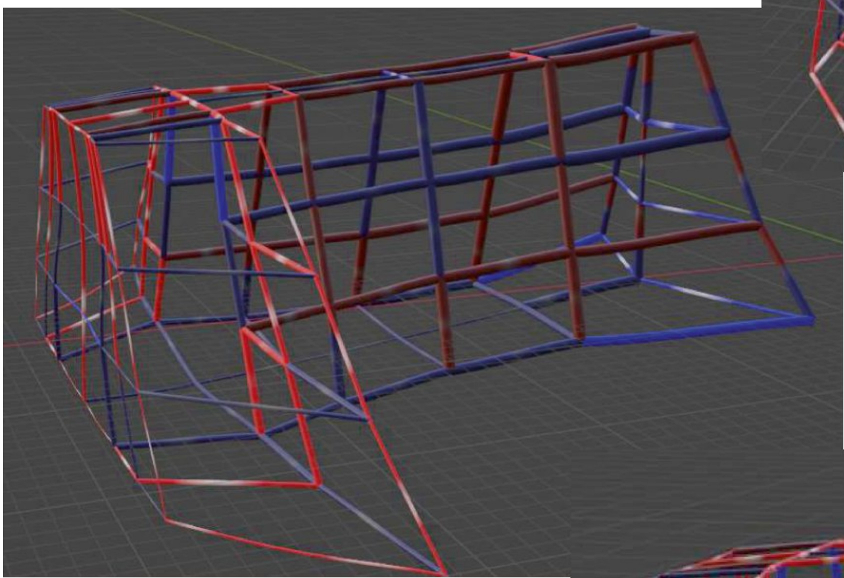
loadcase:

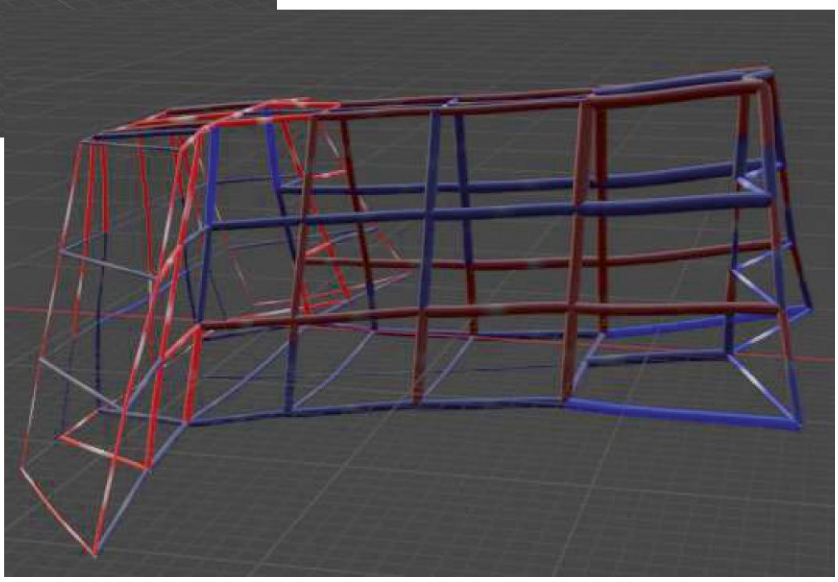
F(Innen) = 9kN/ m²
F(Top)= 4,5kN/ m²

Phaenotyp Report:
file:///C:/Users/marti/Documents/Studium/Diplomarbeit/6_Modulentwicklung%20und%20Tragwerk/Material%20u%20Algorithmen/Blender%20Explorations/091122/report/axial.html



Complex Sectional Preformance first run Load Analysis - simple Rectangle frame





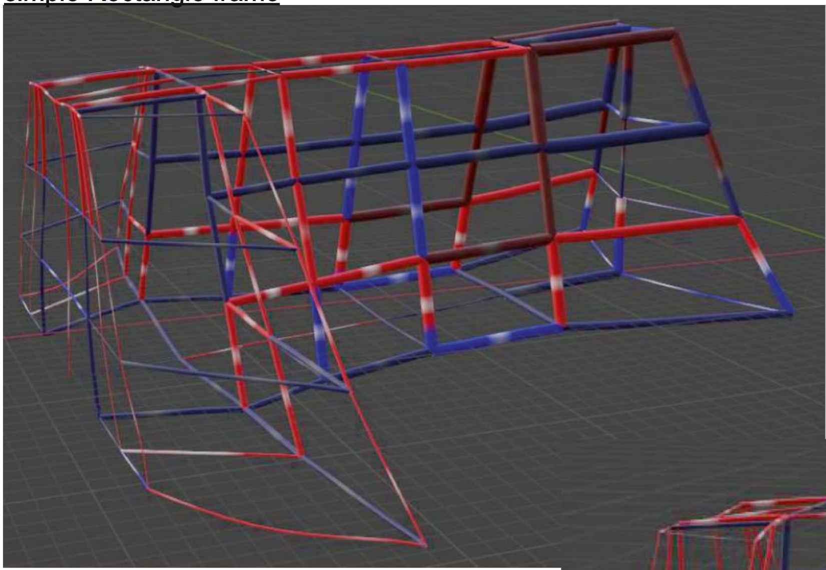
Phaenotyp Blender
FEM-analysis:
Var 1-rectangular simple grid
Complex sectional performance
ran 1 time

loadcase:

F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²

156: Phaenotyp Structural Model # 1

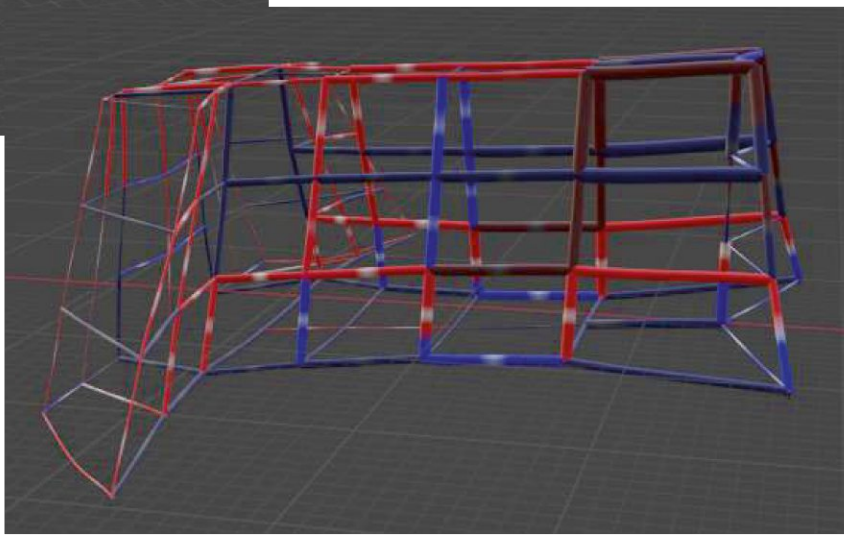
Complex Sectional Preformance second run Load Analysis - simple Rectangle frame



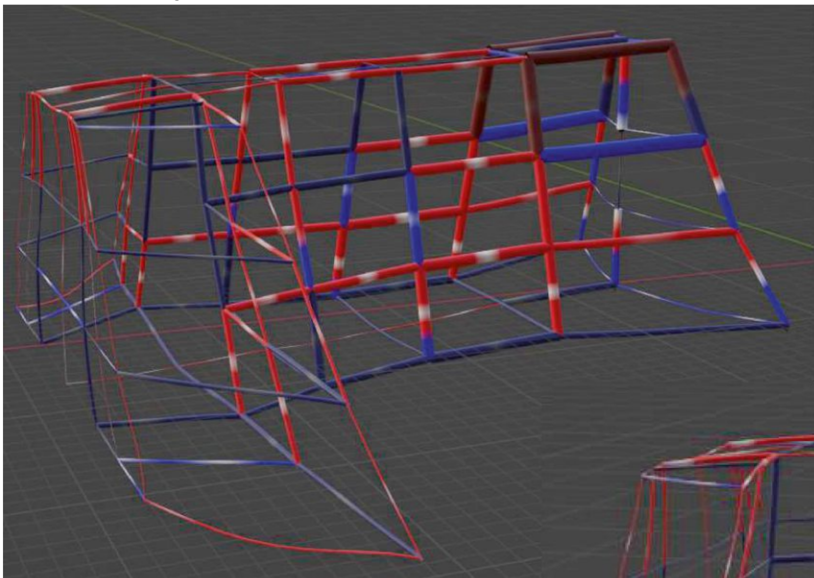
Phaenotyp Blender FEM-analysis:
Var 1 - rect simple grid
Complex sectional performance
ran 2 times

loadcase:

F(indoor) = 9kN/ m²
F(roof) = 4,5kN/ m²



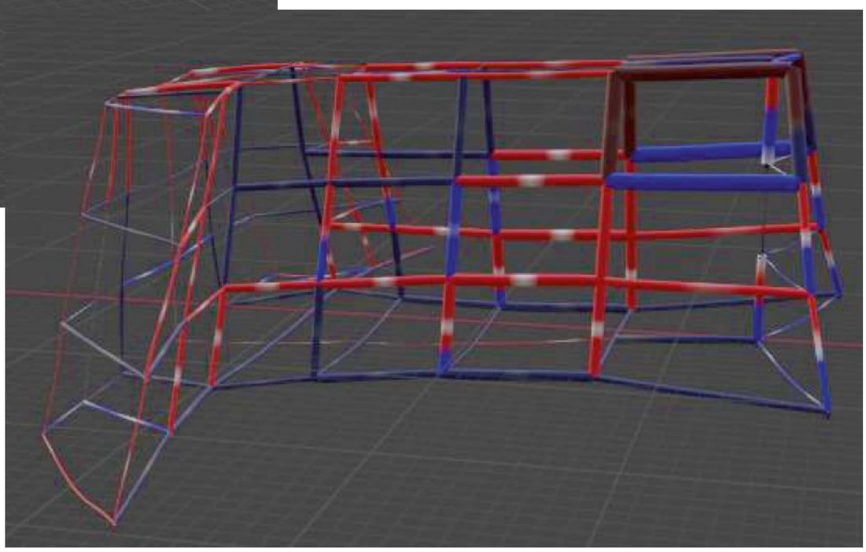
Complex Sectional Preformance third run Load Analysis - simple Rectangle frame



Phaenotyp Blender FEM-analysis:
Var 1 - rect simple grid
Complex sectional performance
ran 3 times

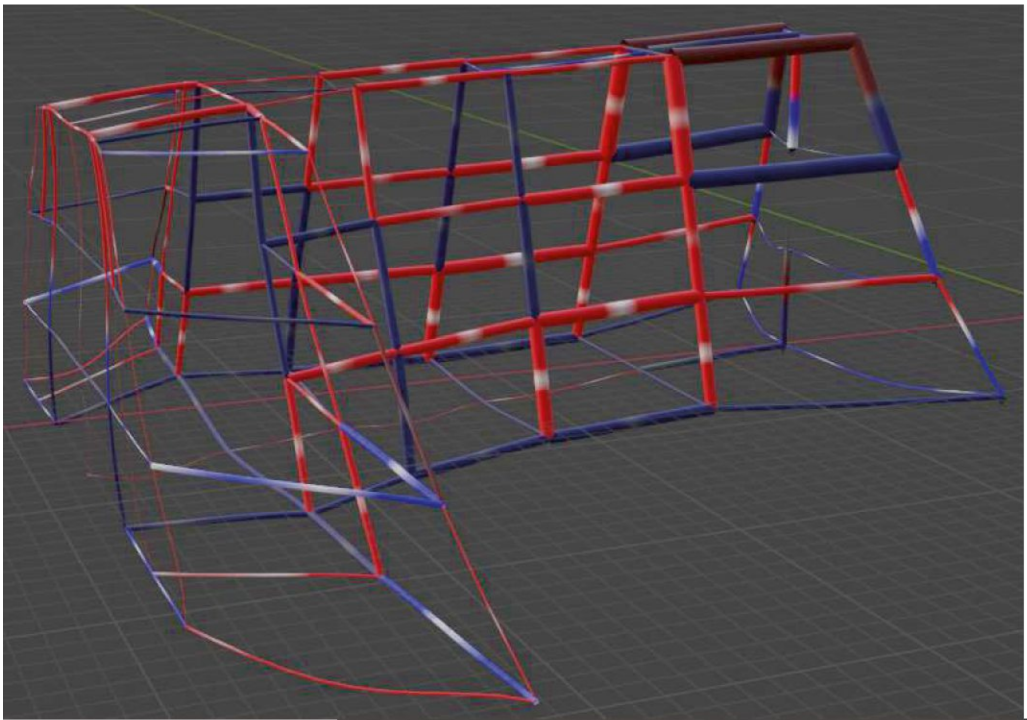
loadcase:

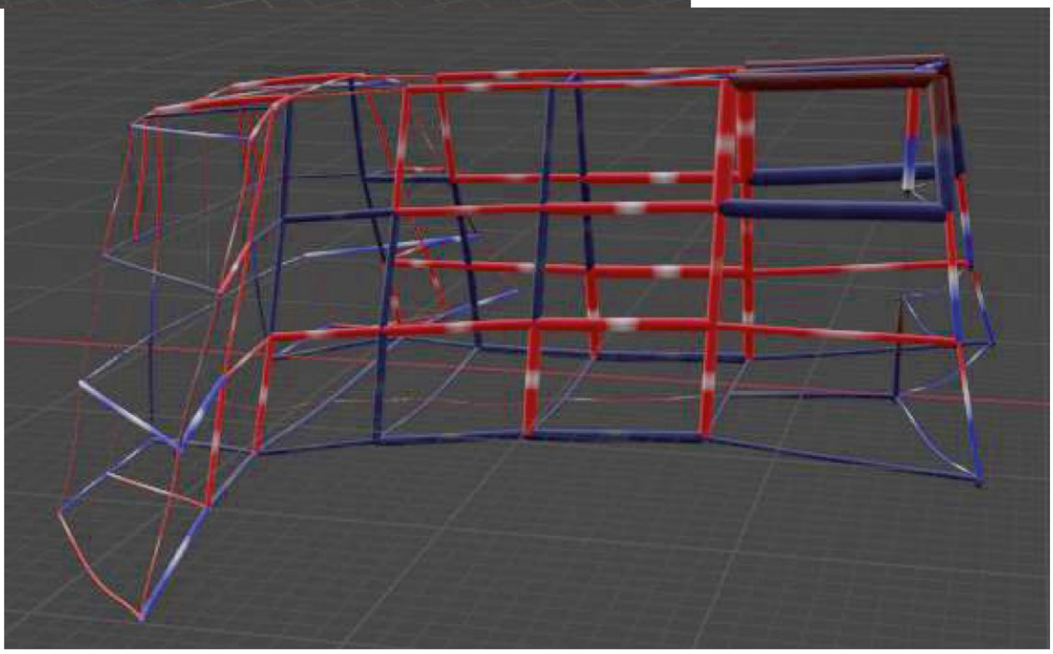
F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²



157: Phaenotyp Structural Model # 1.1

Complex Sectional Preformance 4th run Load Analysis -





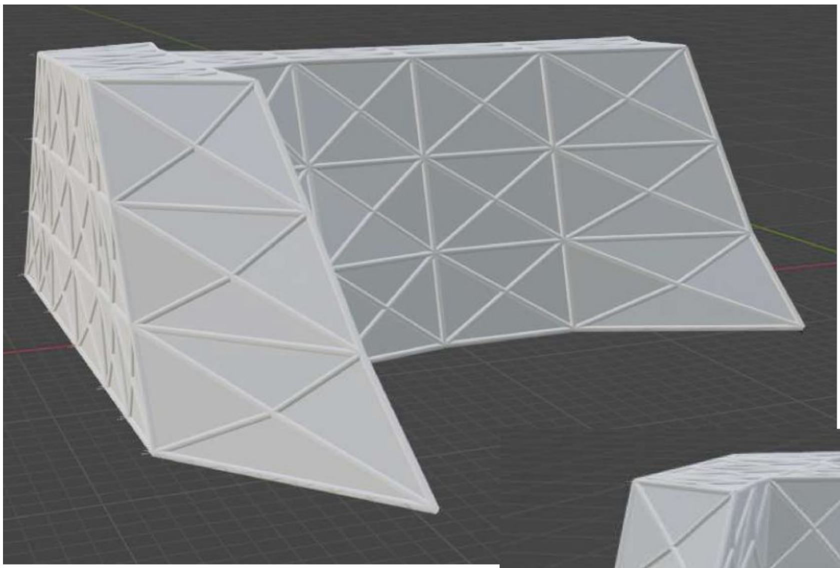
Phaenotyp Blender
FEM-Analyse:
Var 1 - rect simple grid
Complex sectional performance
ran 4 times

loadcase

F(indoor) = 9kN/ m²
F(roof) = 4,5kN/ m²

158: Phaenotyp Structural Model # 1.2

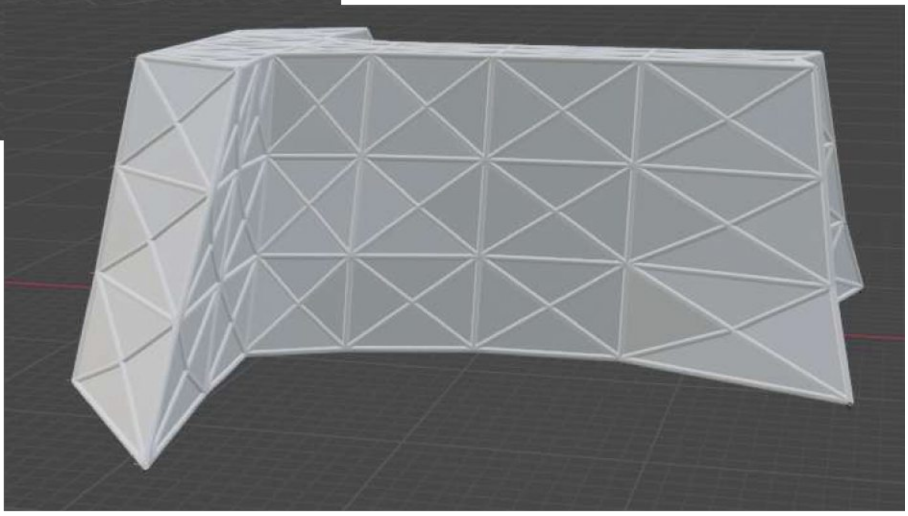
Crossections for Diagrid 1



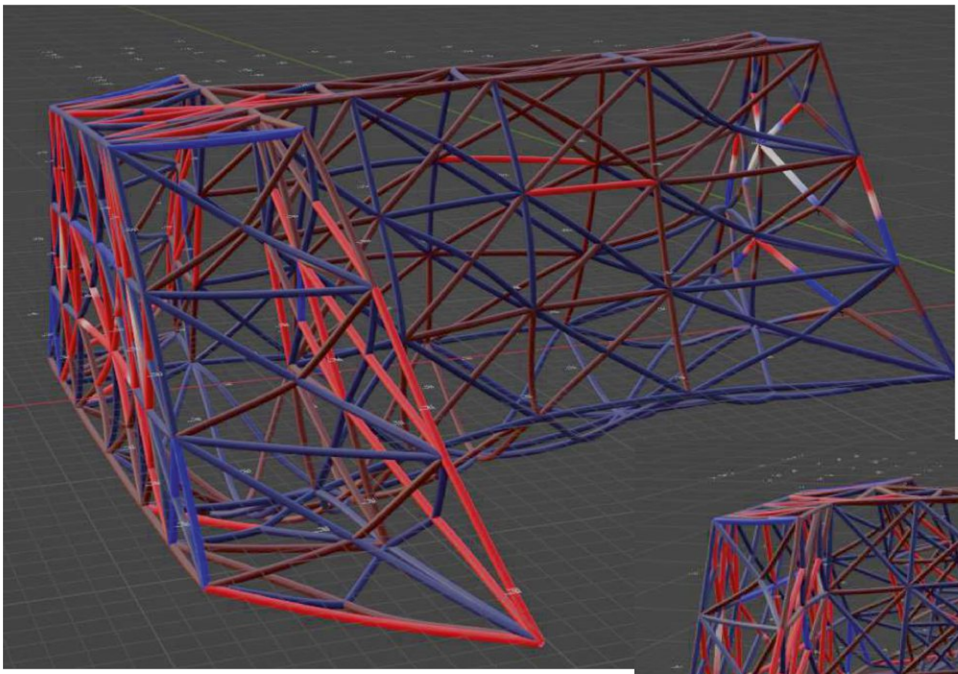
Phaenotyp Blender
FEM-analysis:
Var 2 - diagrid
Assigned Crossec-tions

loadcase:

F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²



Single Frame Load Analysis - simple diagrid frame

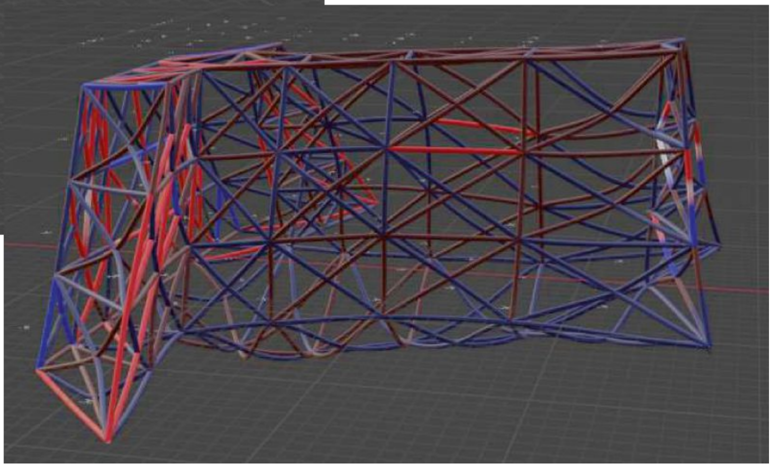


Phaenotyp Blender
FEM-analysis:
Var 2 - diagrid

Single Frame simu-lation

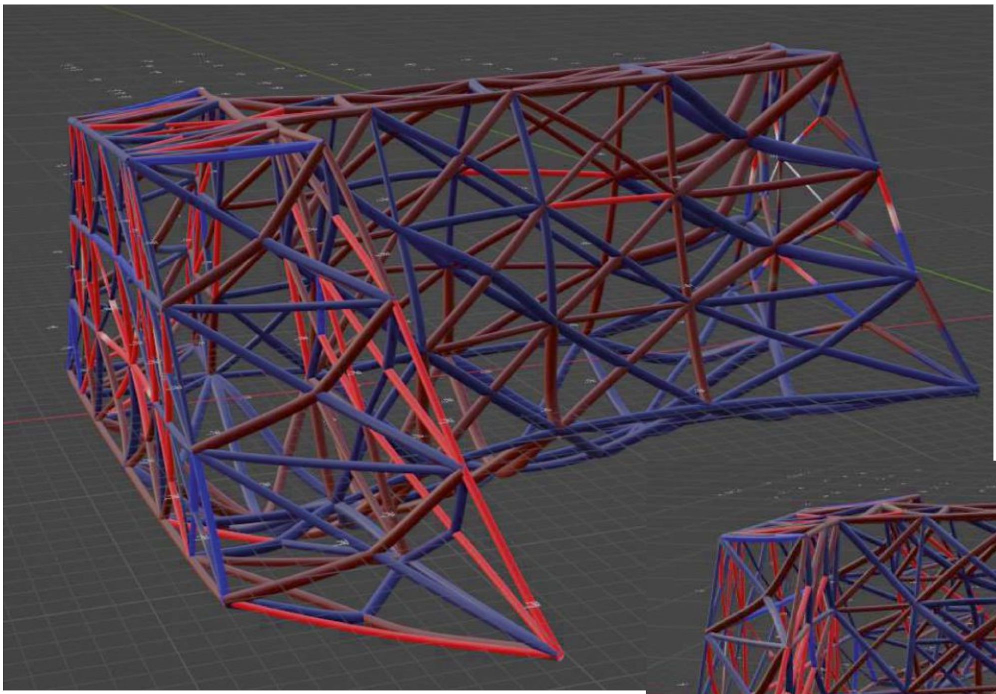
loadcase:

F(indoor) = 9kN/ m²
F(roof) = 4,5kN/ m²



159: Phaenotyp Structural Model # 2

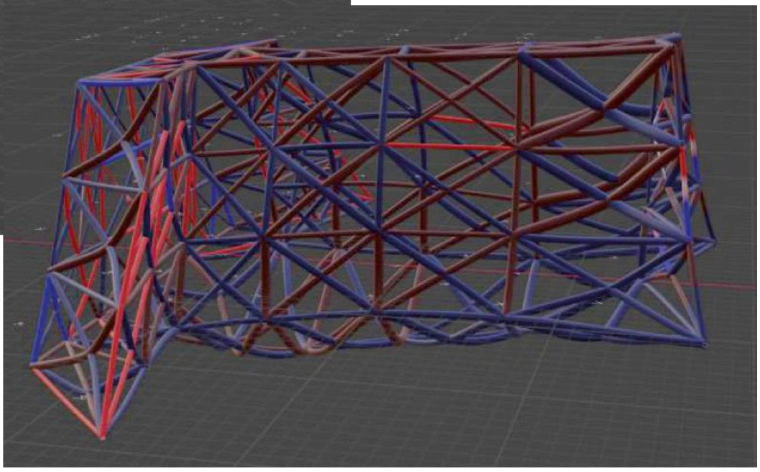
Complex Sectional Preformance first run Load Analysis - simple diagrid frame



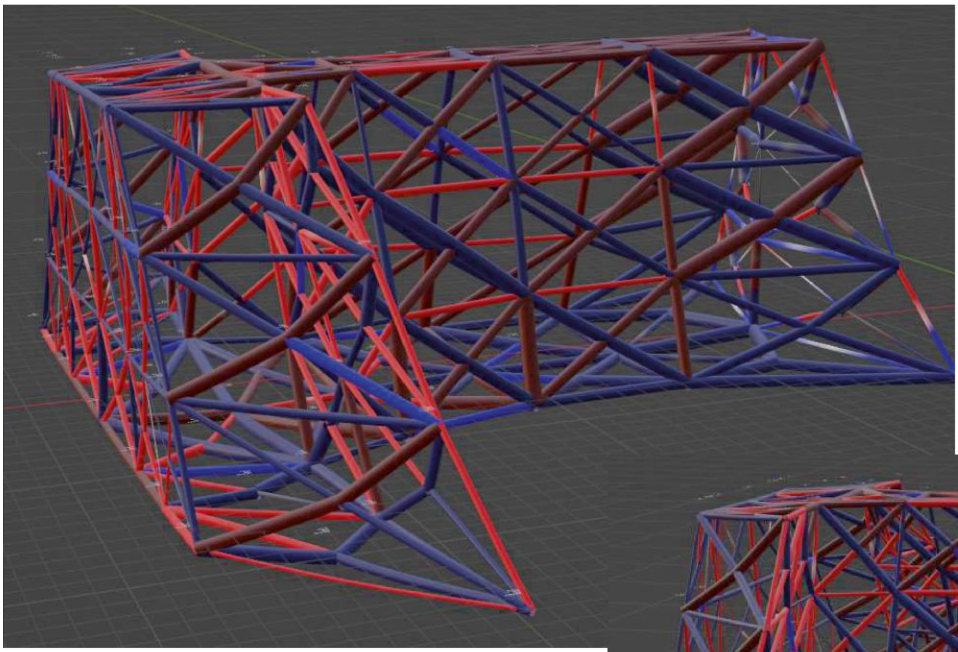
Phaenotyp Blender
FEM-analysis:
Var 2 - diagrid
Complex sectional performance
ran 1 time

loadcase:

F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²



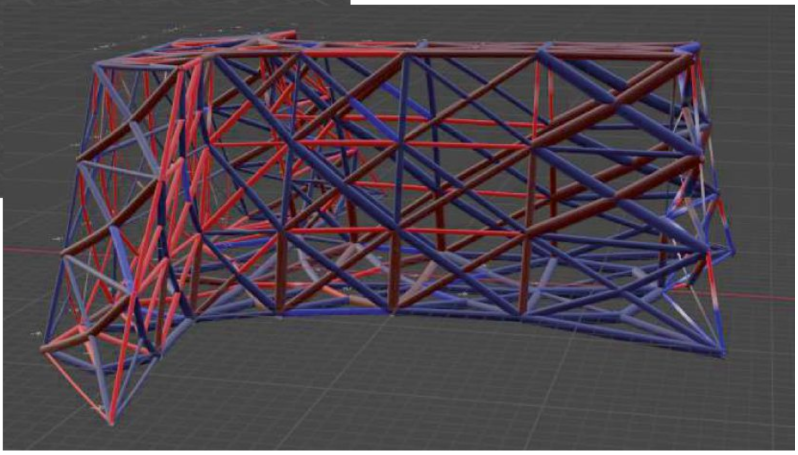
Complex Sectional Preformance second run Load Analysis - simple diagrid frame



Phaenotyp Blender
FEM-analysis:
Var 2 - diagrid
Complex sectional performance
ran 2 times

loadcase:

F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²

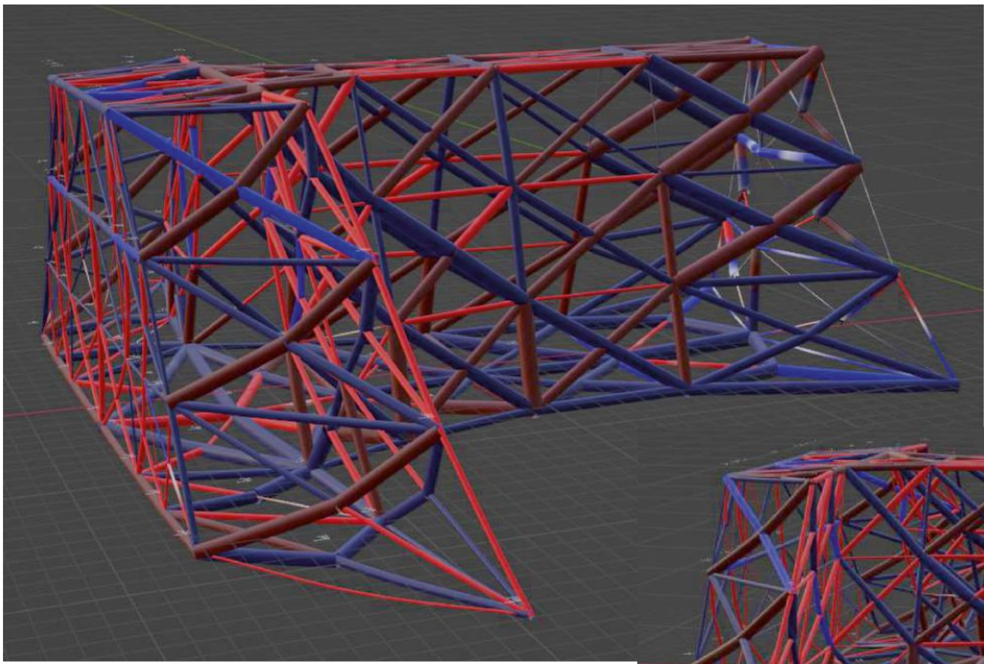


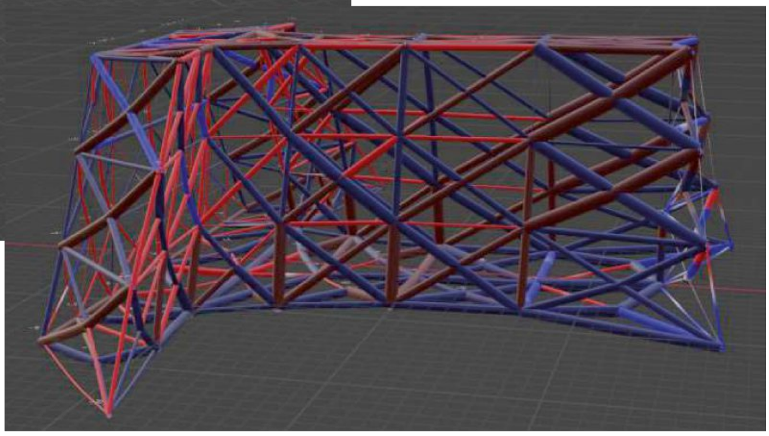
160: Phaenotyp Structural Model # 2.1

Complex Sectional Preformance third run Load Analysis - simple diagrid frame

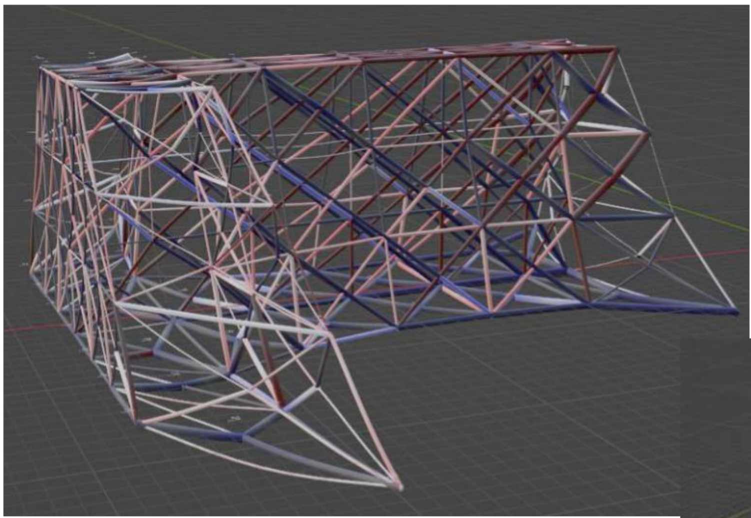
Phaenotyp Blender FEM-Analysis:

Var 2 - diagrid
Complex sectional





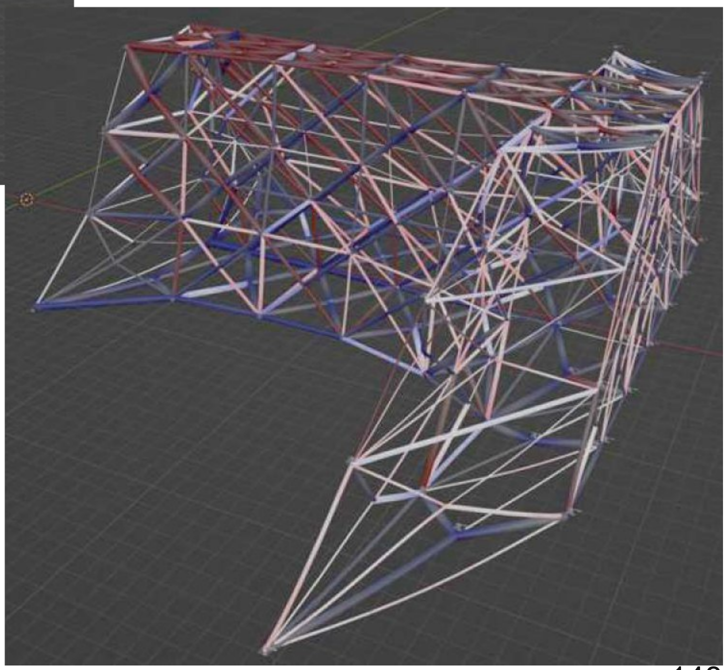
Complex Sectional Preformance fourth run Load Analysis - simple diagrid frame



Phaenotyp Blender FEM-Analysis:
Var 2 - diagrid
Complex sectional performance
ran 4 times

loadcase:

F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²



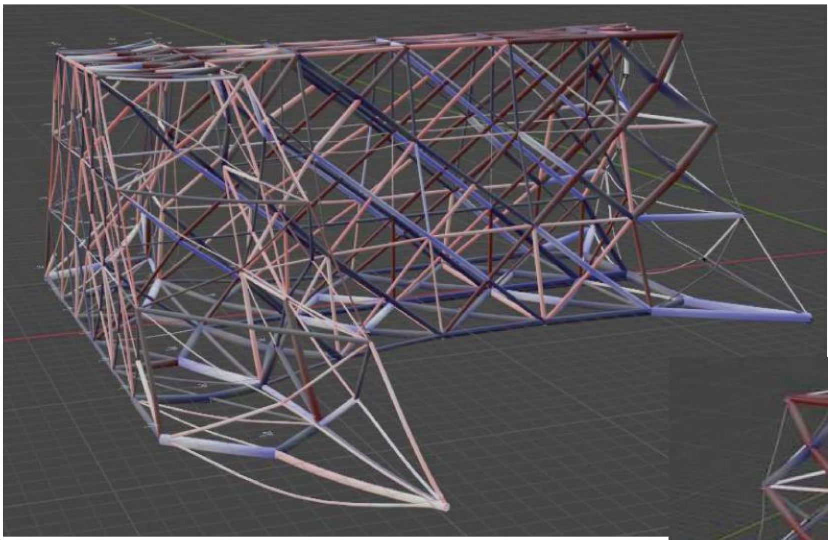
161: Phaenotyp Structural Model # 2.2

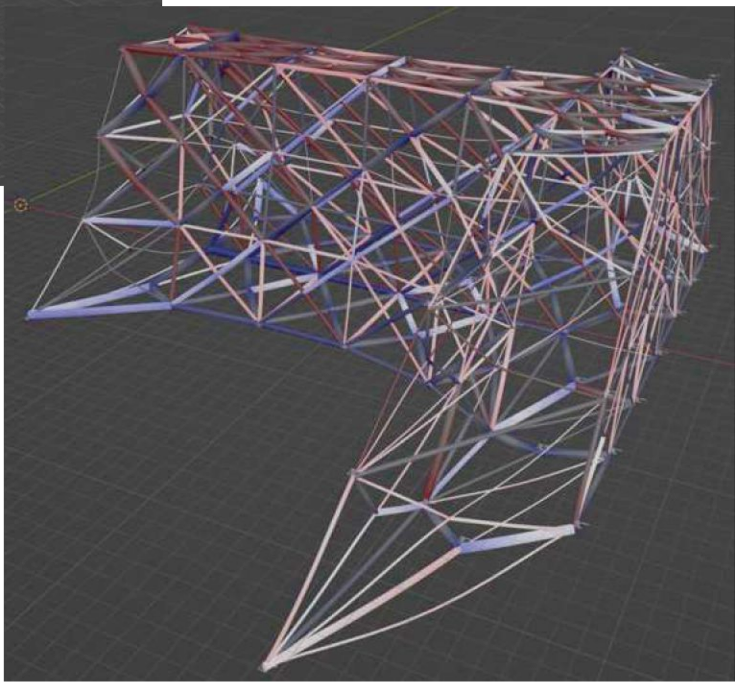
Complex Sectional Preformance fifth run Load Analysis -

Phaenotyp Blender
FEM-Analyse:
Var 2 - diagrid
Complex sectional performance
ran 5 times

loadcase:

F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²





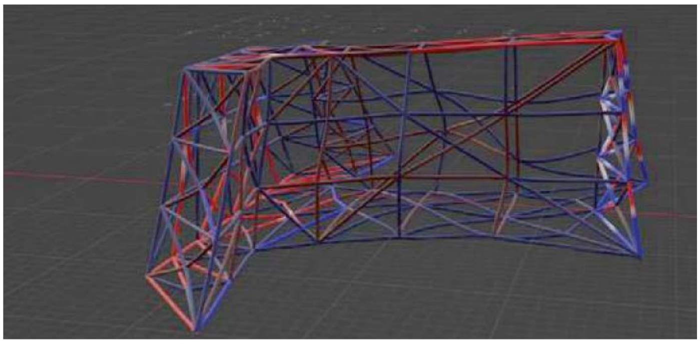
162: Phaenotyp Structural Model # 2.3

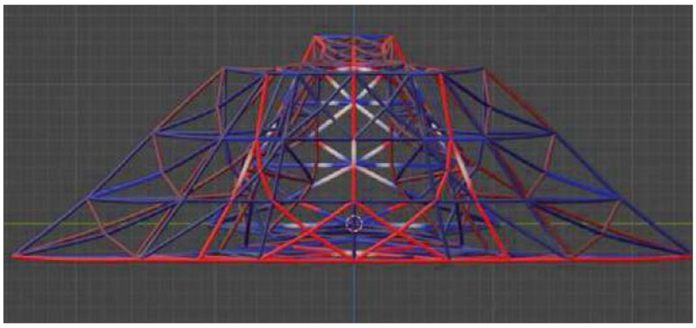
Single Frame Load Analysis - reduced diagrid frame

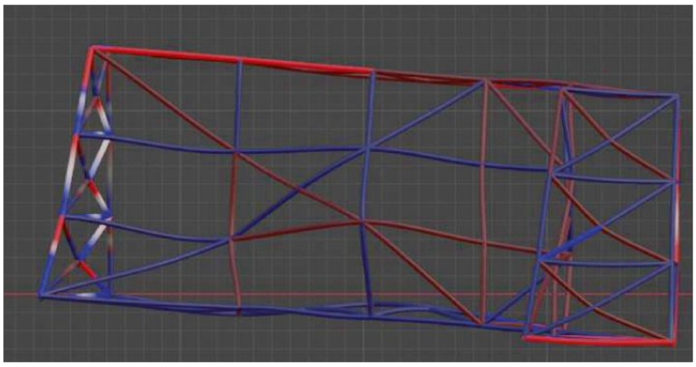
Phaenotyp Blender
FEM-analysis:
Var 3-reduced diagrid
Singel frame Analysis

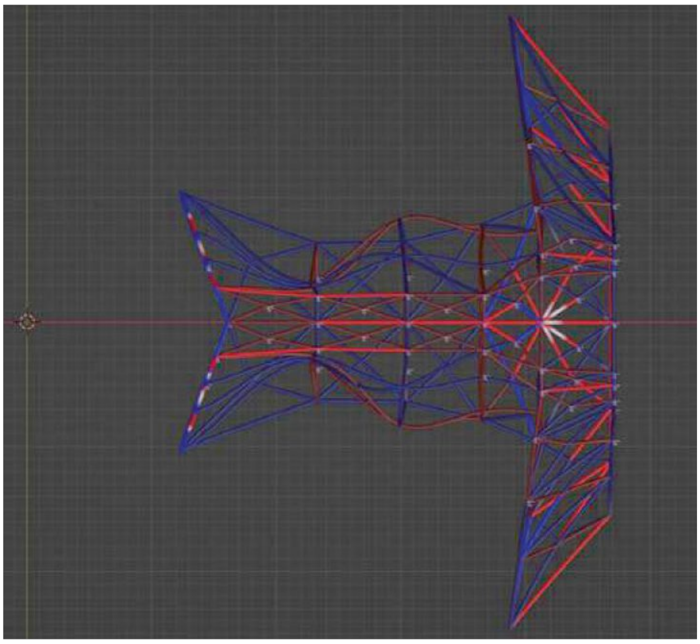
loadcase:

F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²







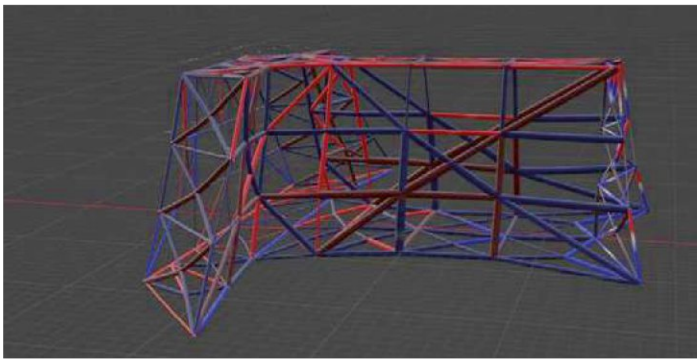


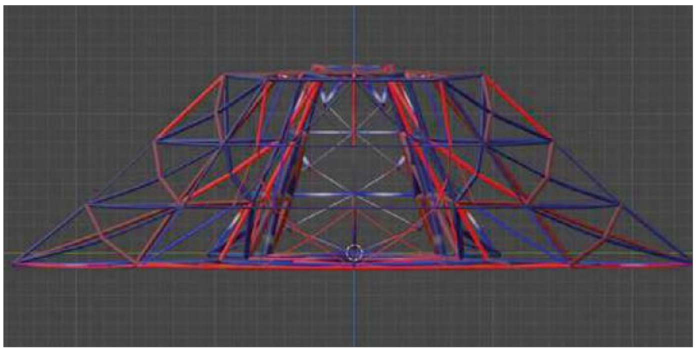
Complex Sectional Preformance second run Load Analysis - reduced diagrid frame

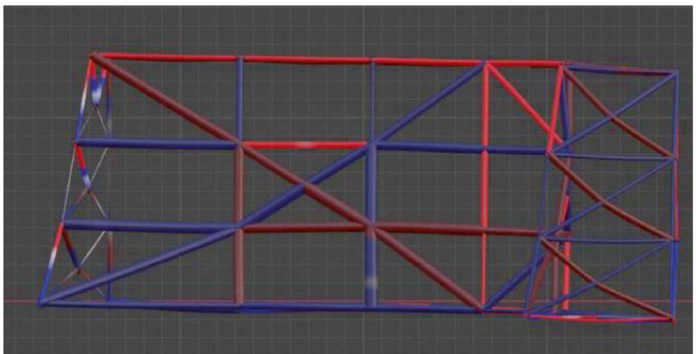
Phaenotyp Blender
FEM-analysis:
Var 3-reduced diagrid
Complex sectional perfor-mance
ran 2 times

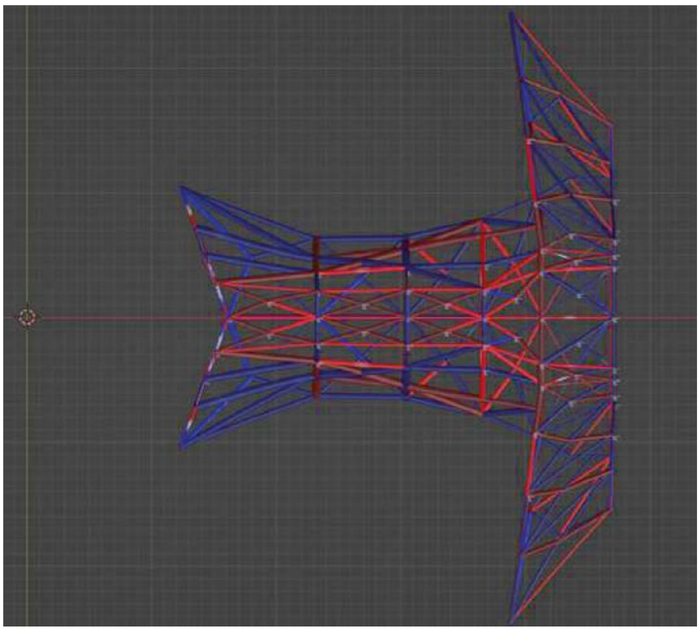
loadcase:

F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²







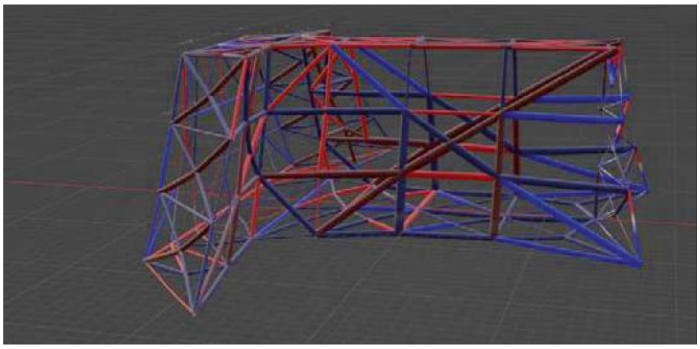


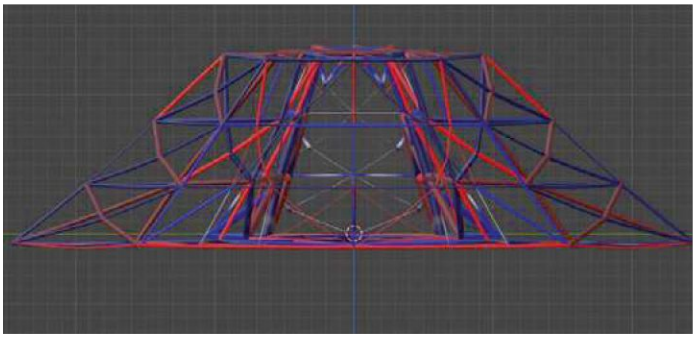
163: Phaenotyp Structural Model # 3

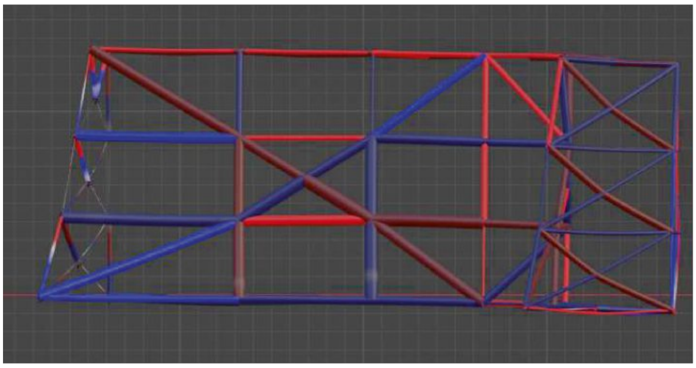
<u>Complex Sectional Preformance third run Load Analysis - reduced diagrid frame</u>

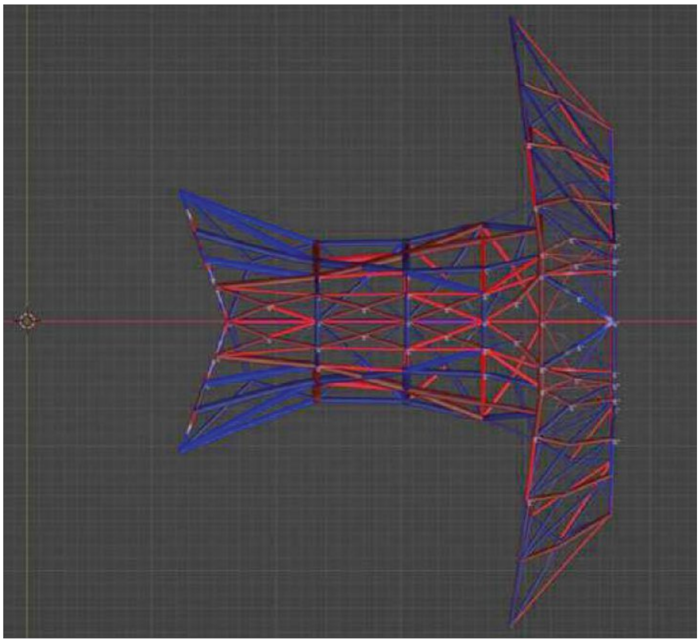
<u>Phaenotyp Blender FEM-analysis:</u>
<u>Var 3-reduced diagrid</u>
Complex sectional performance

ran 3 times
<u>loadcase:</u>
F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²





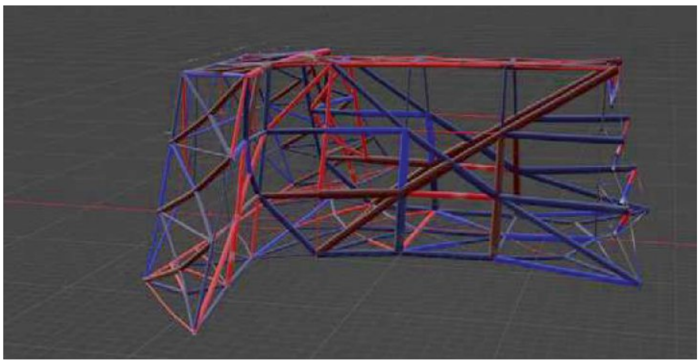


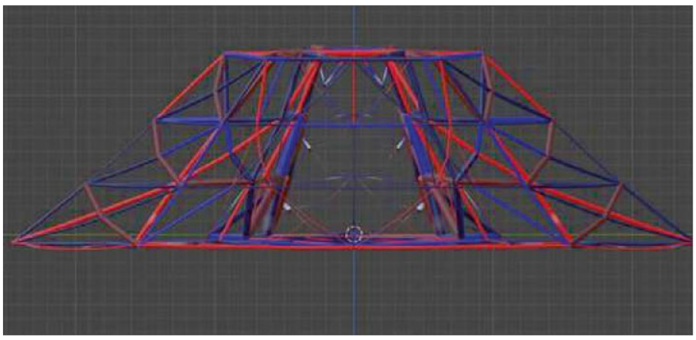


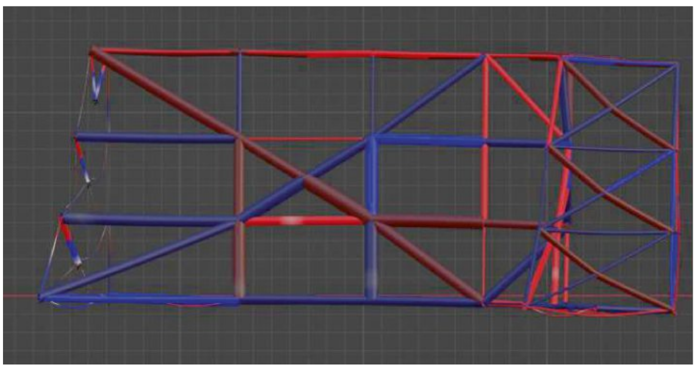
<u>Complex Sectional Preformance fourth run Load Analysis - reduced diagrid frame</u>

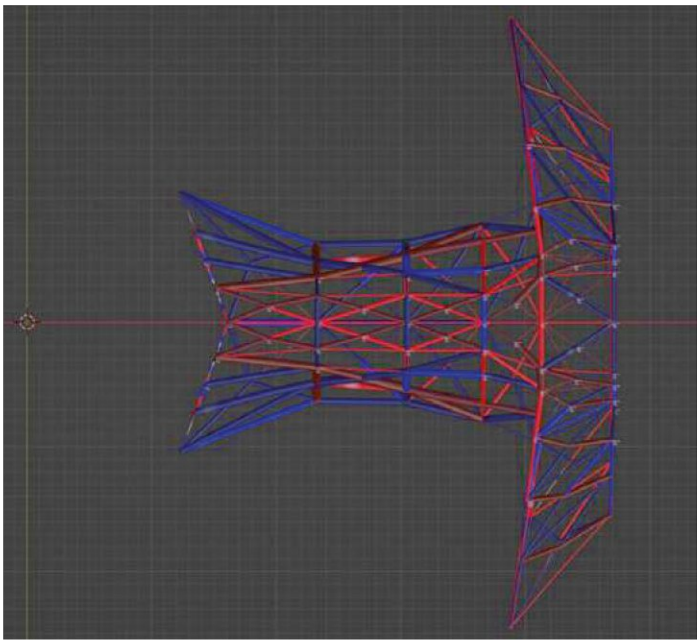
<u>Phaenotyp Blender FEM-analysis:</u>
<u>Var 3-reduced diagrid</u>
Complex sectional performance
ran 4 times

<u>loadcase:</u>
F(indoor) = 9kN/ m²
F(roof)= 4,5kN/ m²





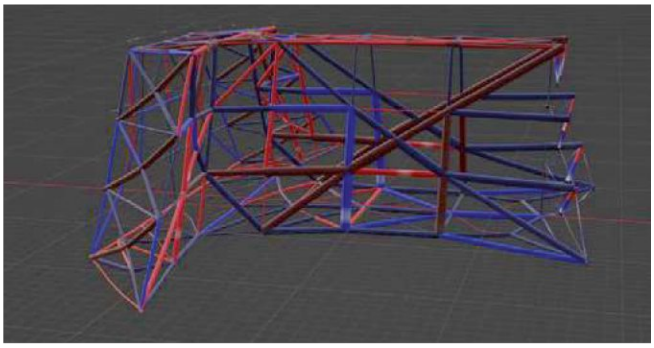


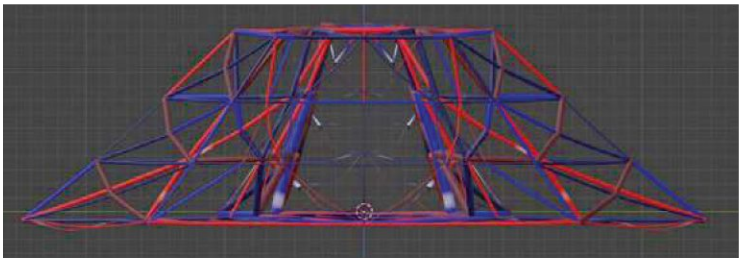


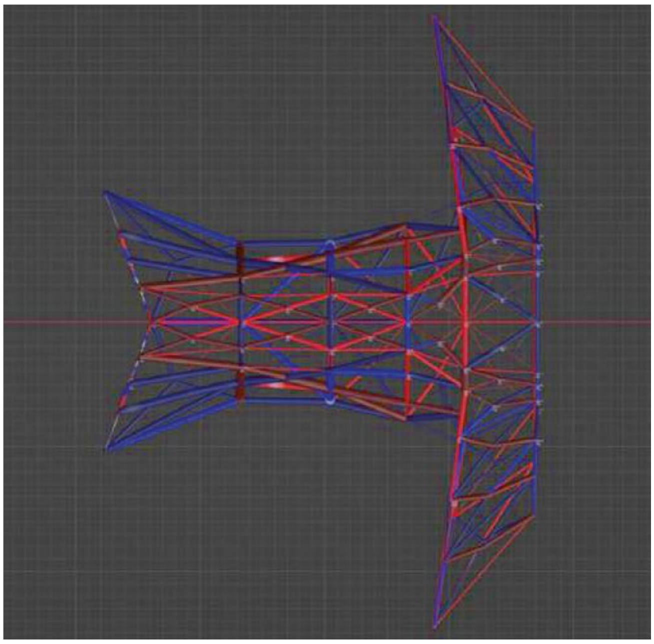
164: Phaenotyp Structural Model # 3.1

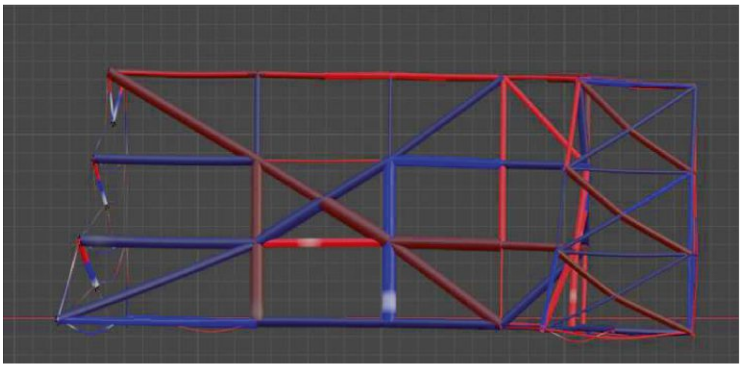
Complex Sectional Preformance fifth run Load Analysis - reduced diagrid frame

Phaenotyp Blender	loadcase:
FEM-analysis:	
Var 3-reduced diagrid	F(indoor) = 9kN/ m²
Decimate topological perfor-mance	F(roof)= 4,5kN/ m²
ran 5 times	





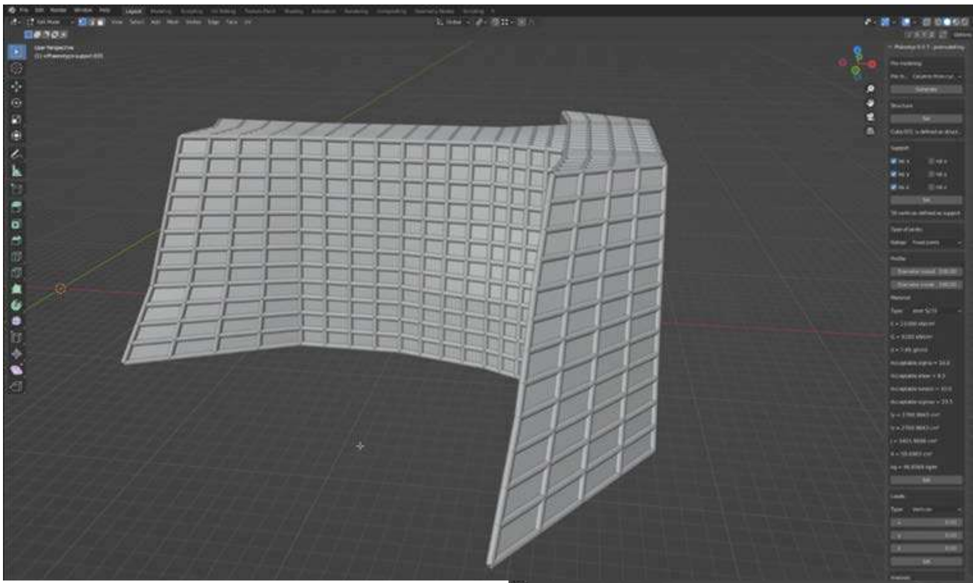




165: Phaenotyp Structural Model # 3.2

Source-model

Subdivided Grid with slabs for bracing



Phaenotyp Blender

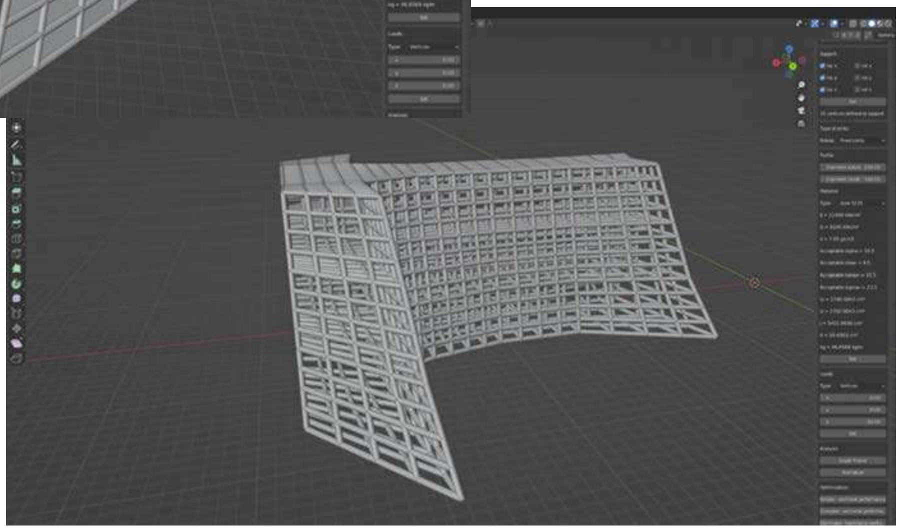
FEM-Analyse:

Var X-subdivided grid

Single frame Analysis

loadcase

F(total) ca 8,1kN/ m² (810 x 10N)



Single Frame Load Analysis -

Subdivided Grid with slabs for bracing

Phaenotyp Blender

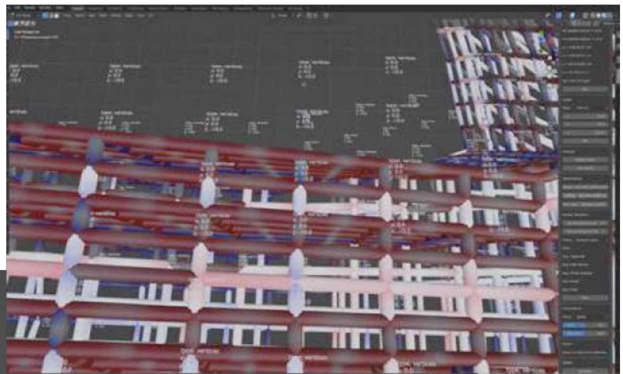
FEM-Analyse:

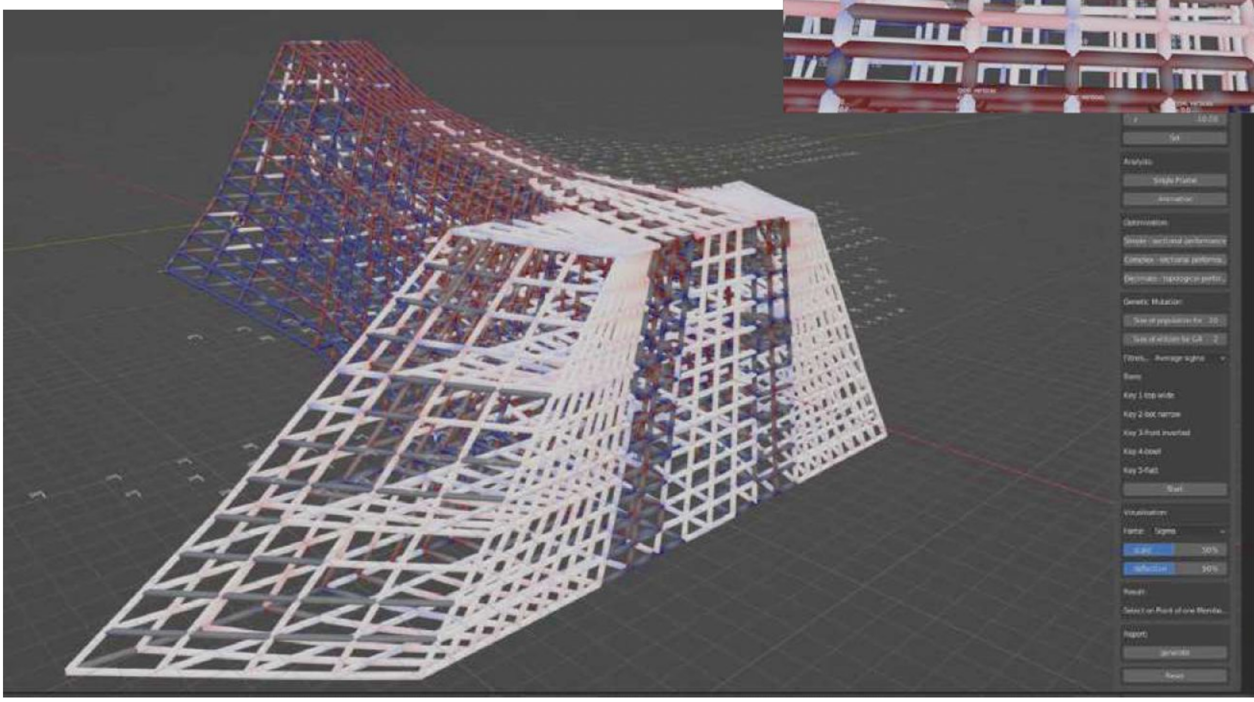
Var X-subdivided grid

Single frame Analysis

loadcase:

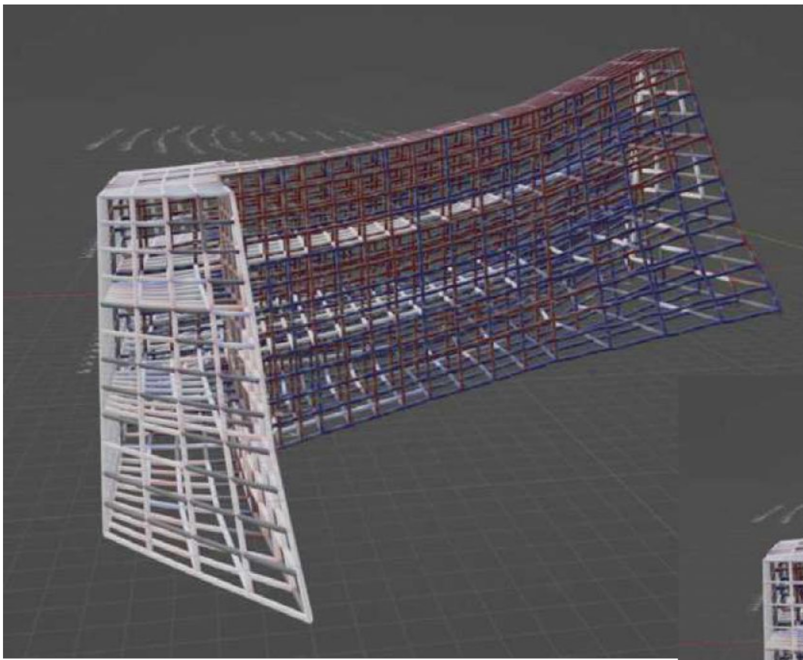
F(total) ca 8,1kN/ m² (810 x 10N)

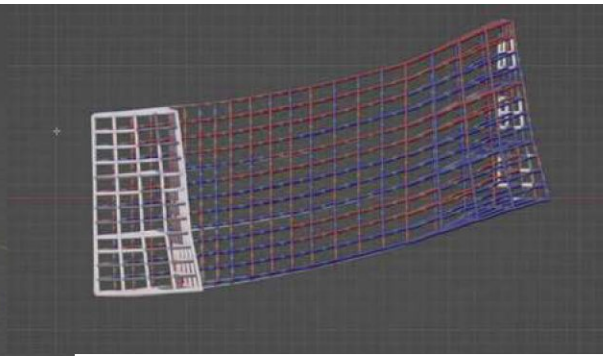


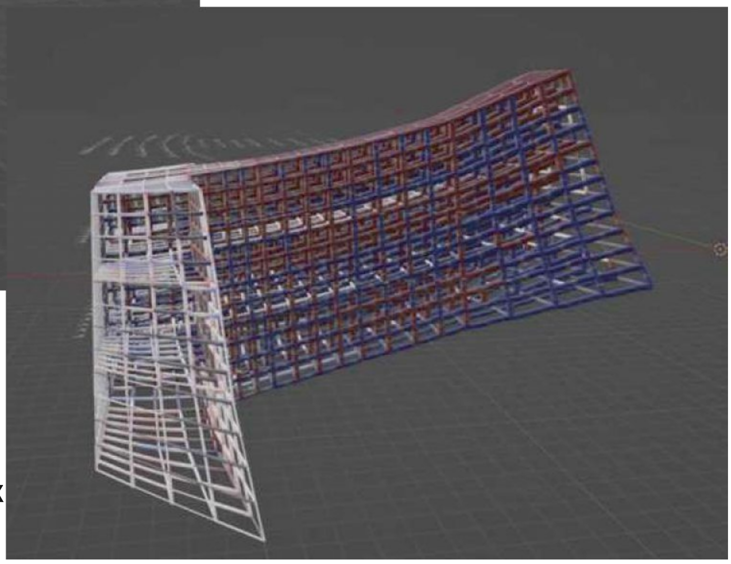


166: Phaenotyp Structural Model # 4

Source-model





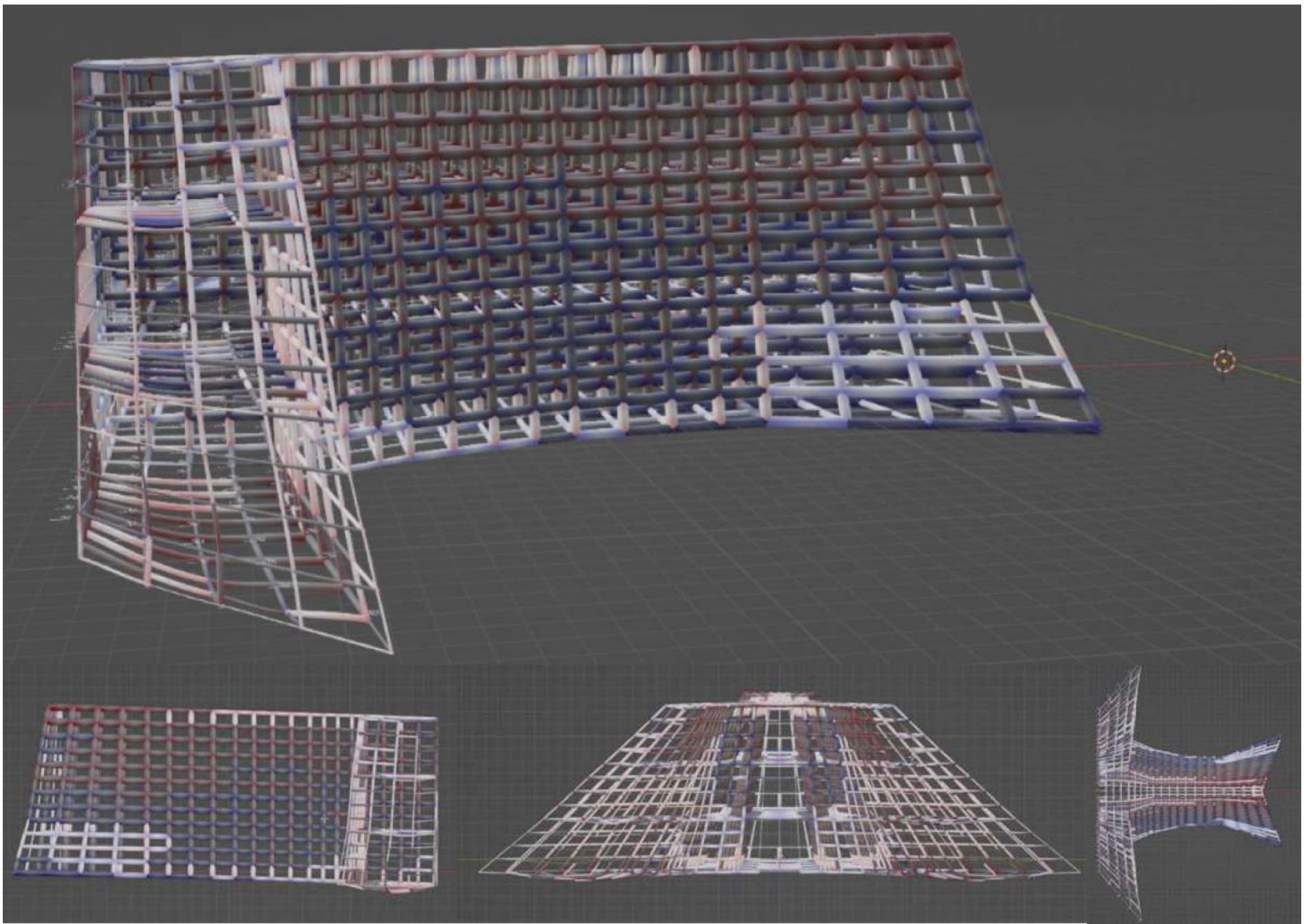


Complex sectional Preformance analysis ran 2-5 times

Phaenotyp Blender
FEM-Analyse:
Var X-subdivided grid
complex sectional performance ran from top left to bottom right: 1x, 1x, 2x, 3x, 4x, 4x, 4x

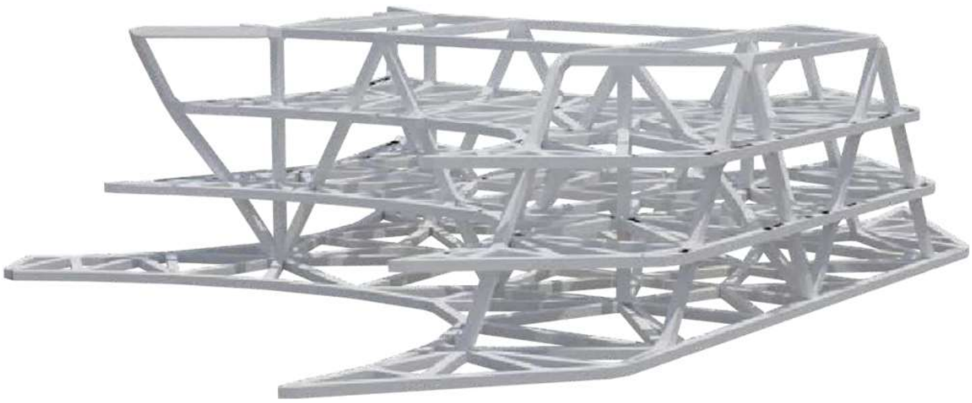
loadcase:

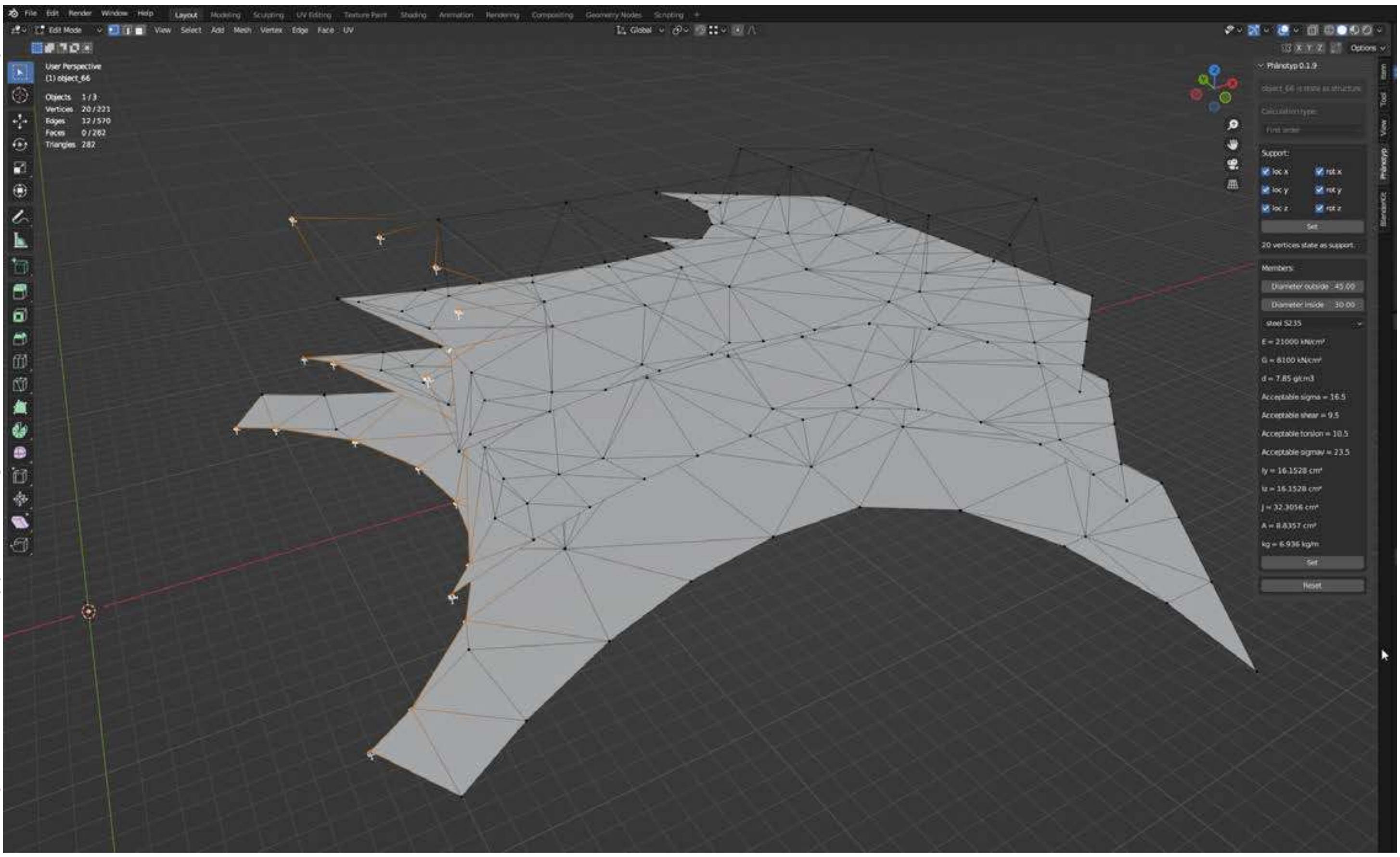
F(total) ca 8,1kN/ m² (810 x 10N)



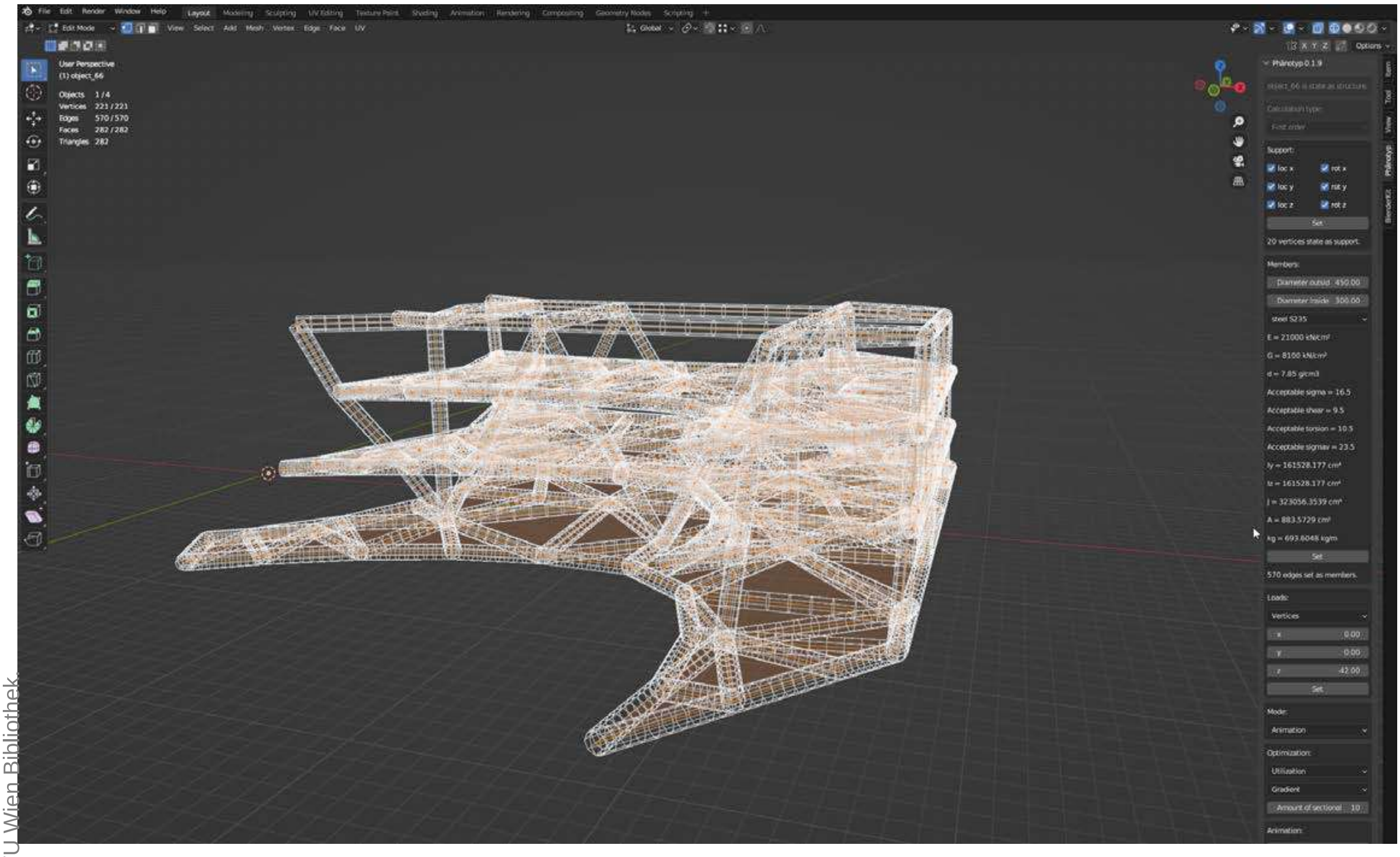
167: Phaenotyp Structural Model # 4.1

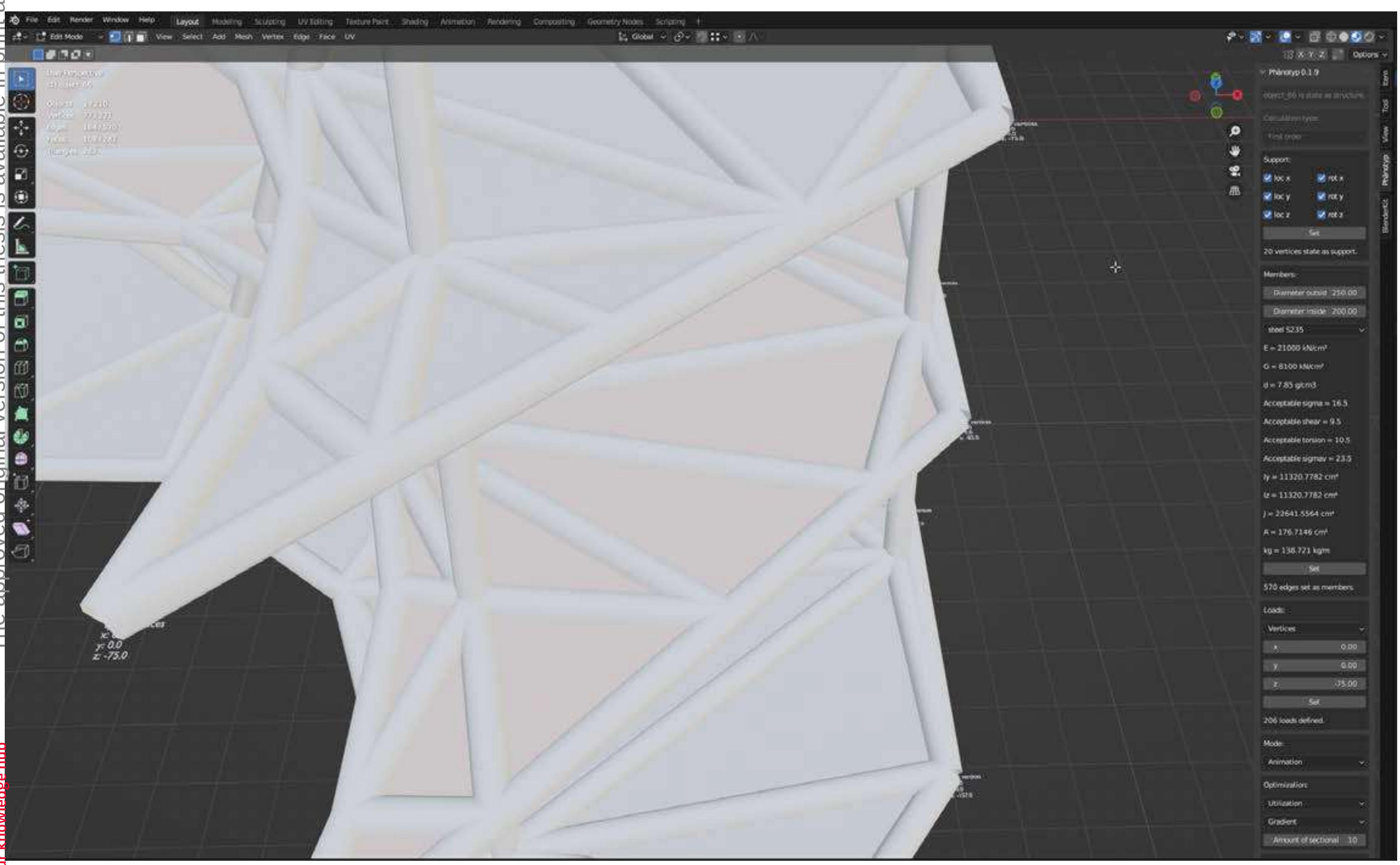
6.2 Final Results of Phaenotyp Analyses



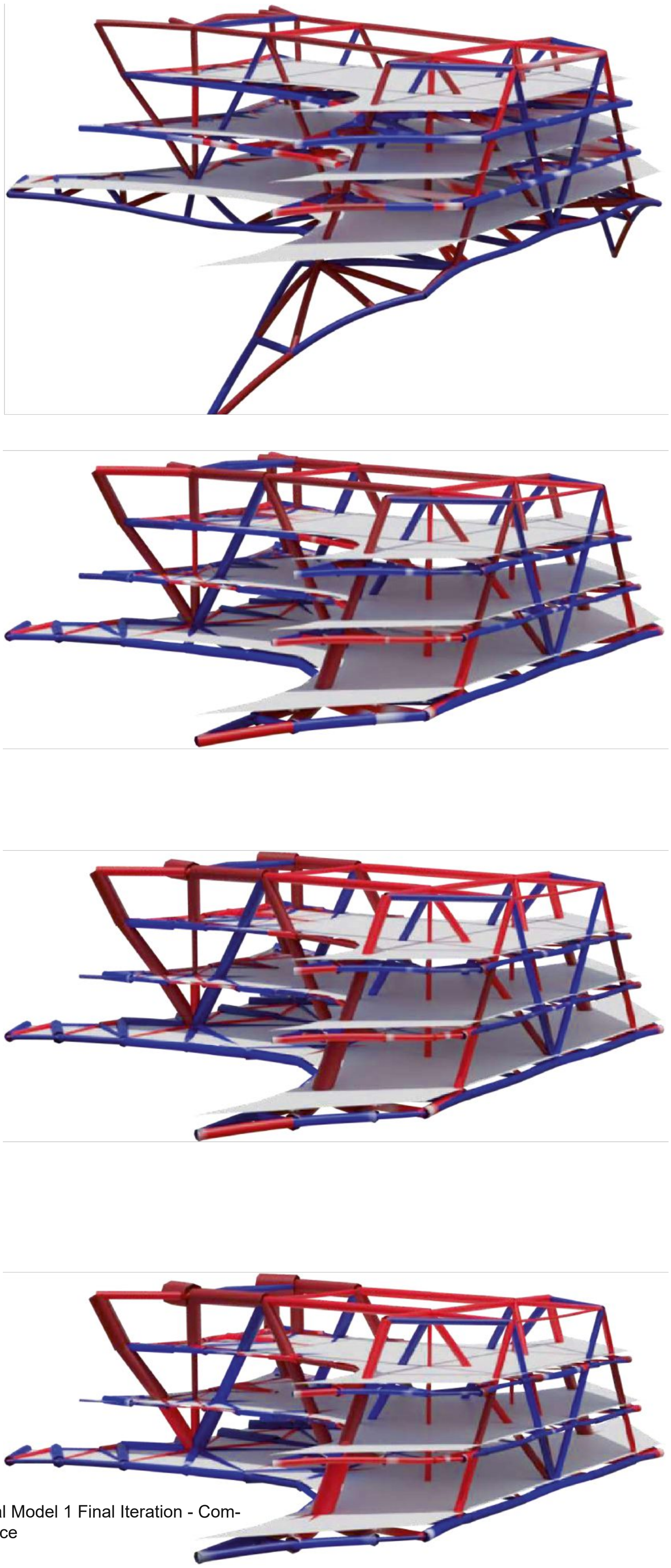


168: Phaenotyp Structural Model 1 Final Iteration - Base Shape and Support Vertices

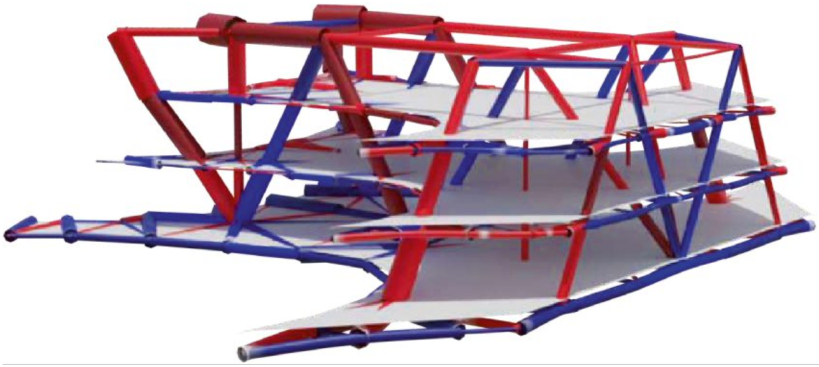


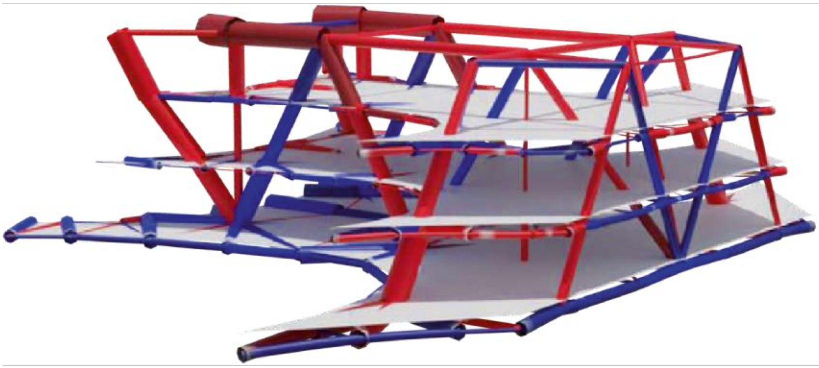


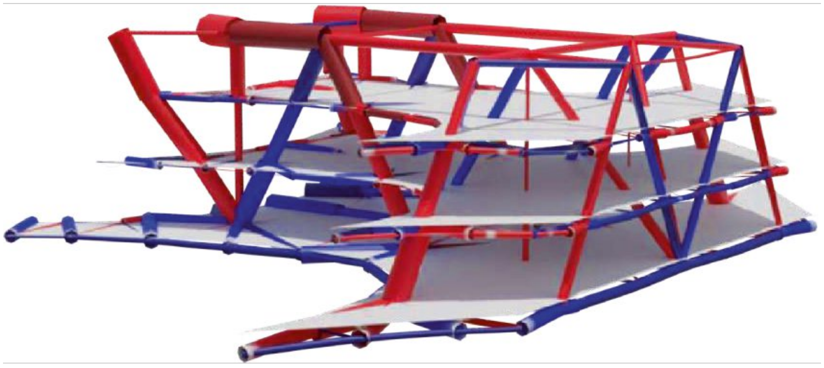
169: Phaenotyp Structural Model 1 Final Iteration - Crossection and Load definition

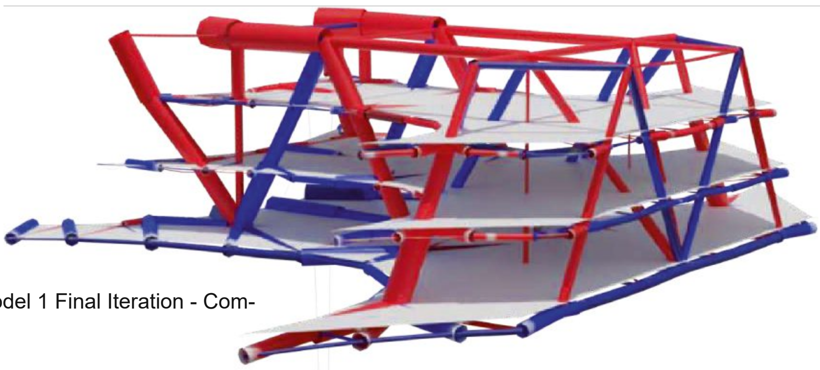


170: Phaenotyp Structural Model 1 Final Iteration - Complex Sectional Performance

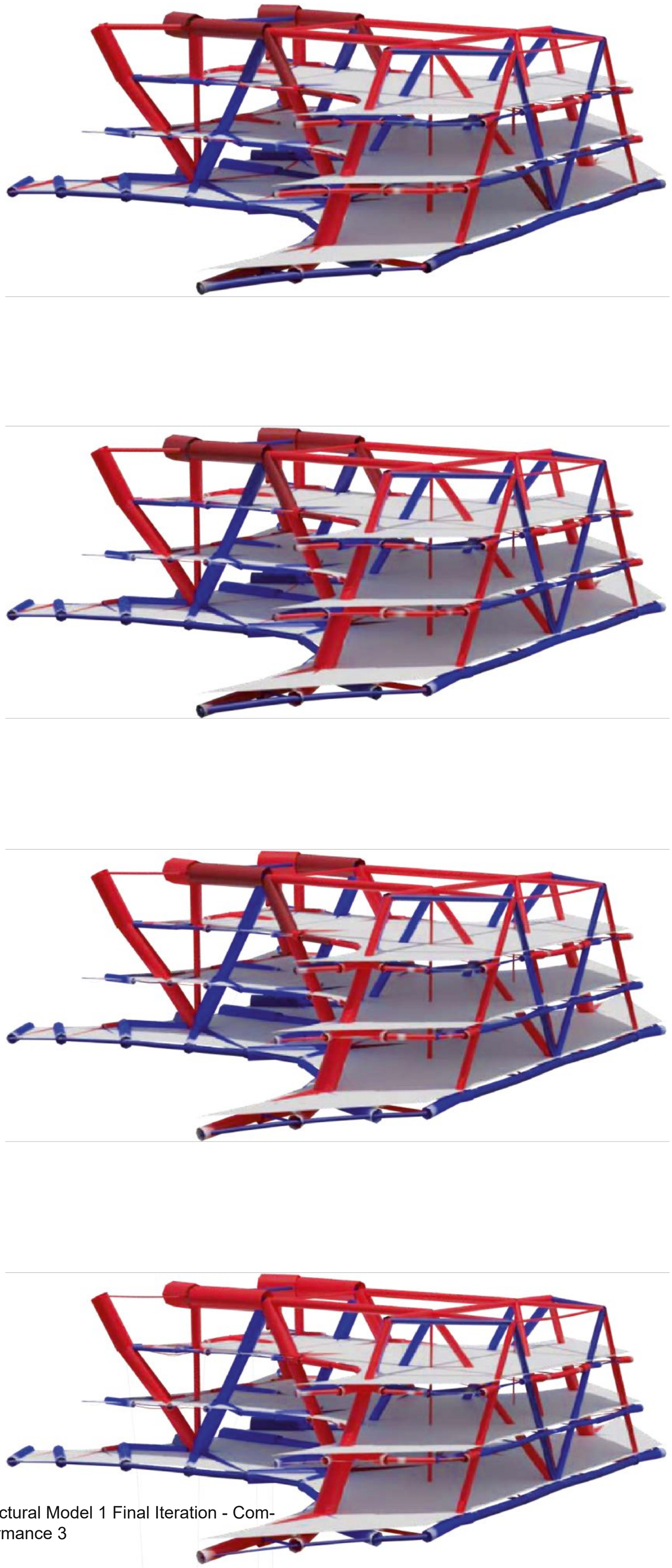




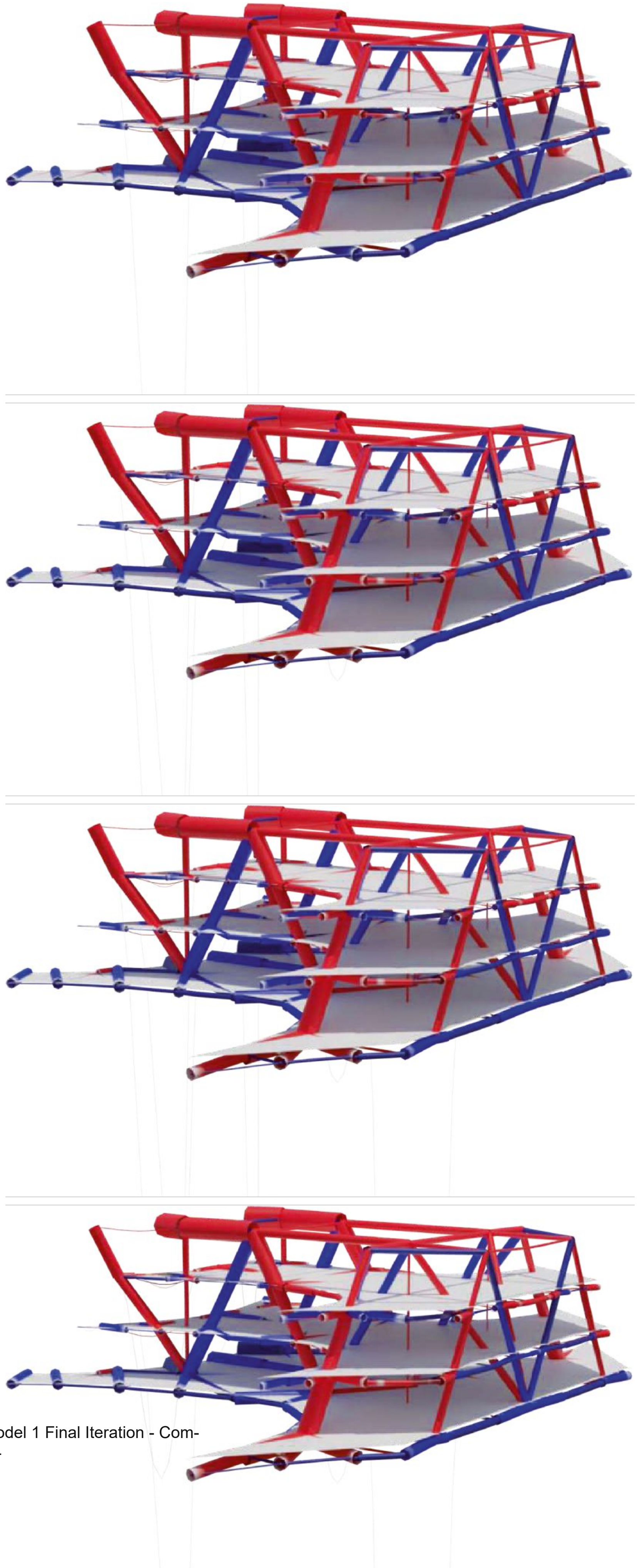




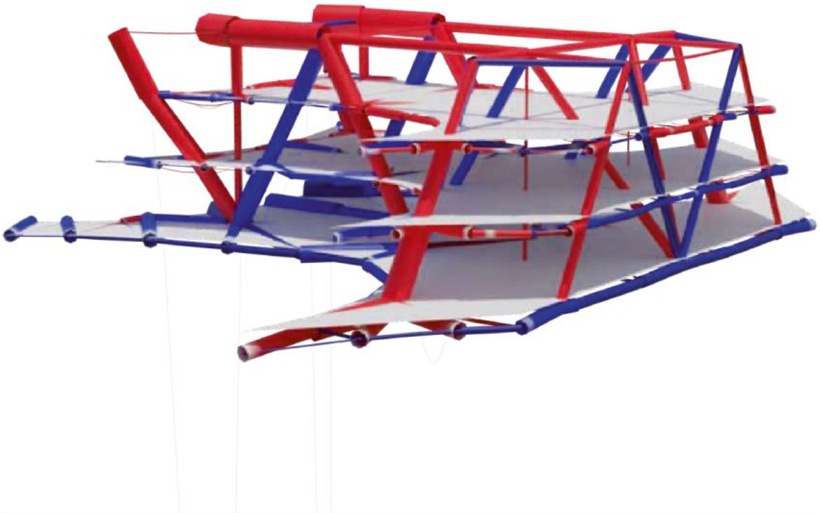
171: Phaenotyp Structural Model 1 Final Iteration - Complex Sectional Performance 2

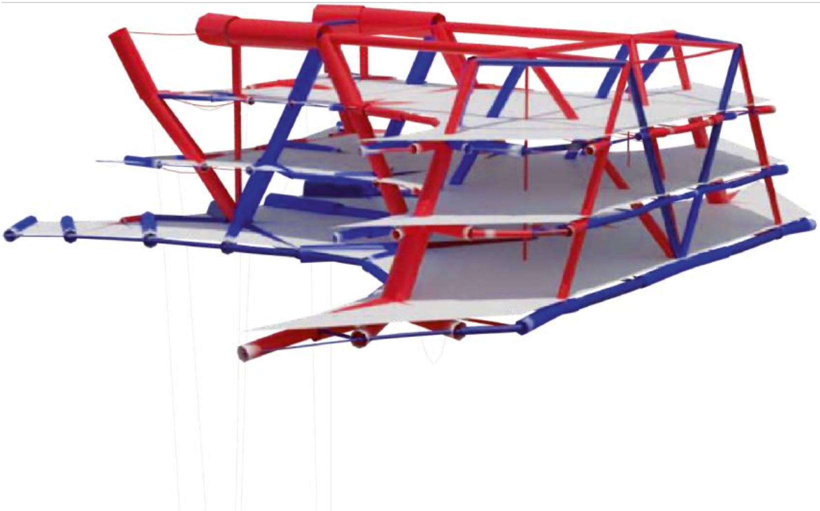


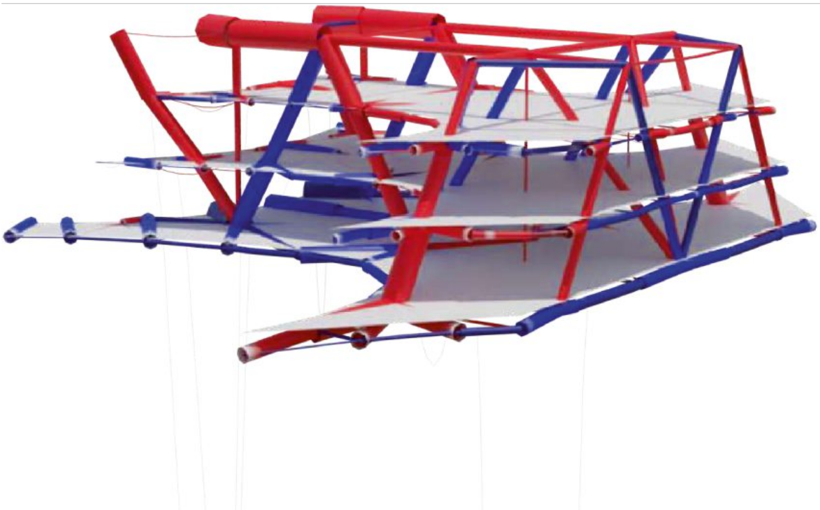
172: Phaenotyp Structural Model 1 Final Iteration - Complex Sectional Performance 3

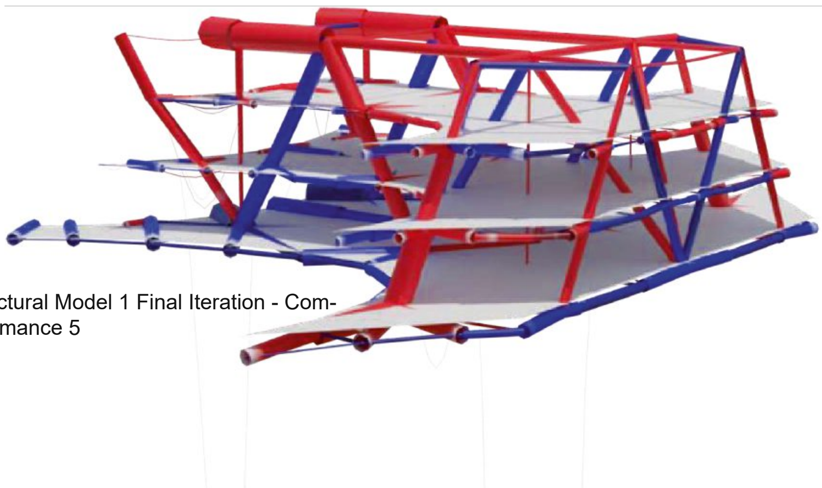


173: Phaenotyp Structural Model 1 Final Iteration - Complex Sectional Performance 4

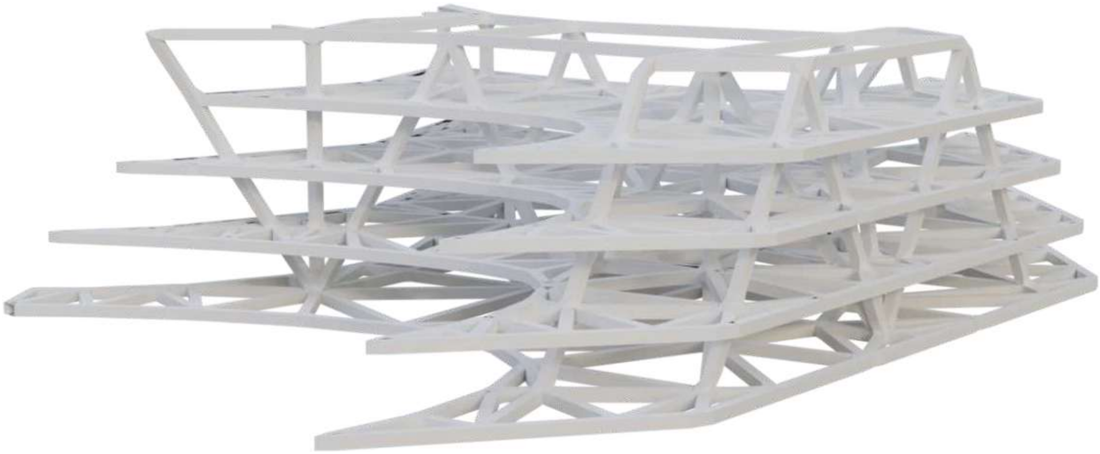


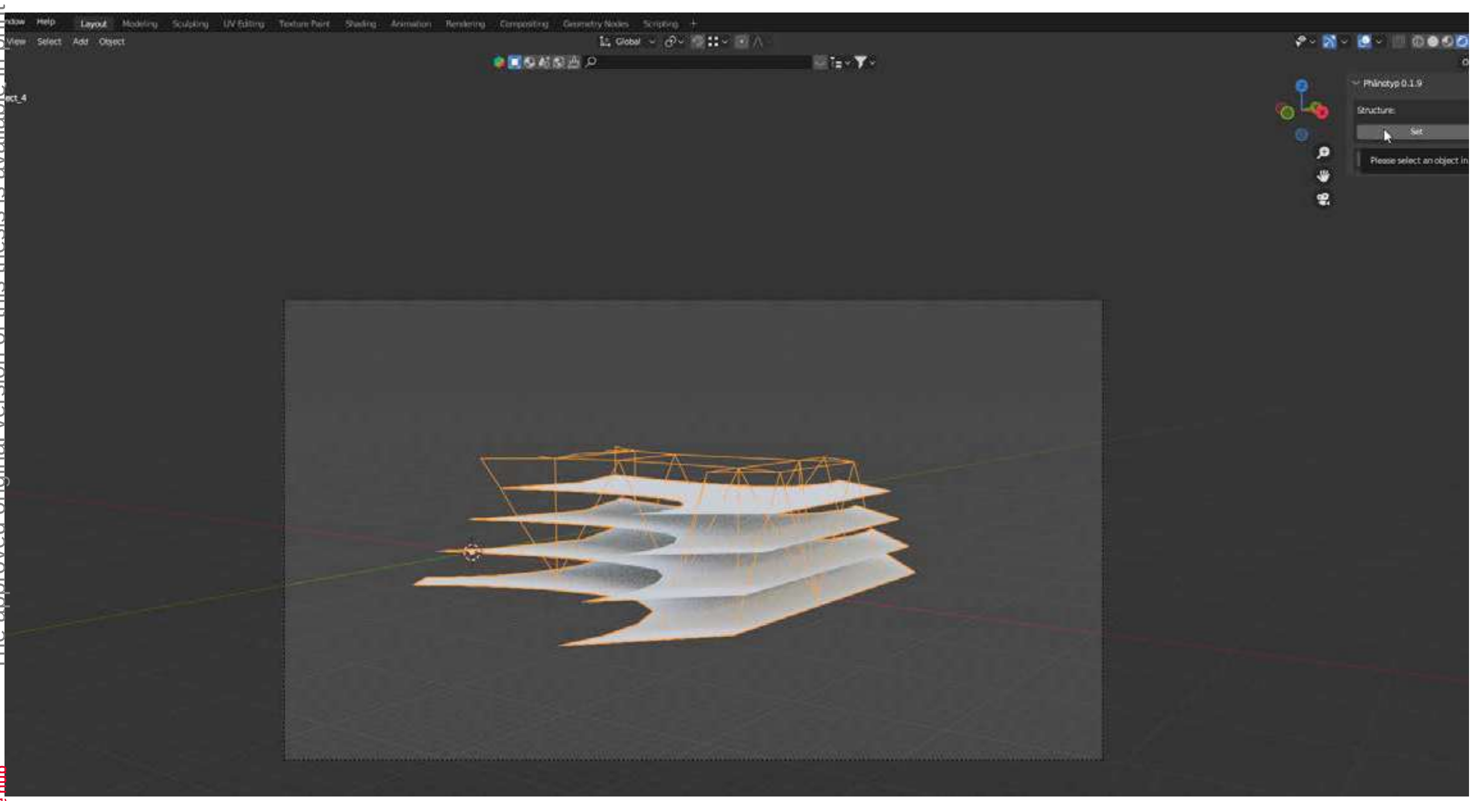




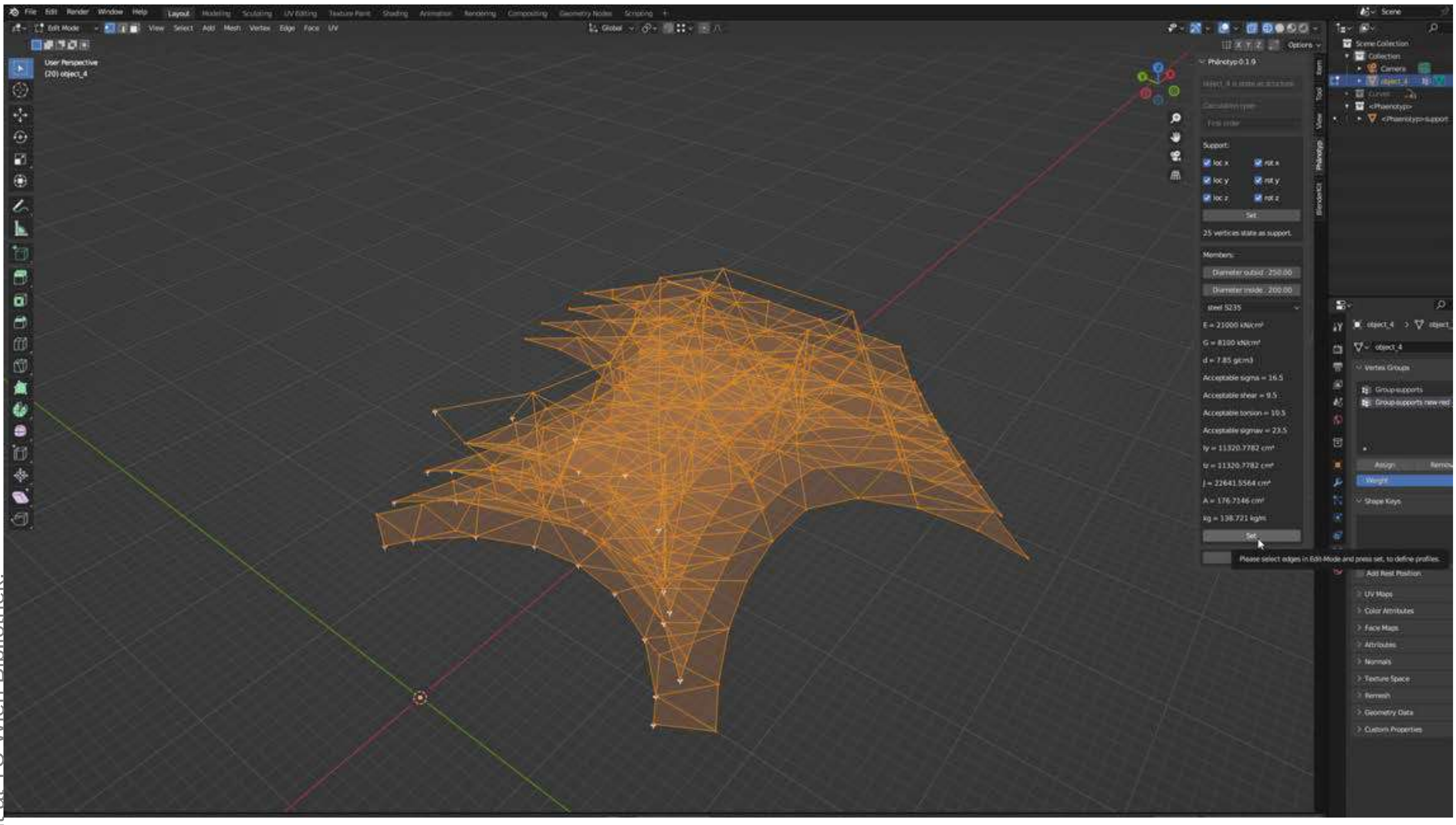


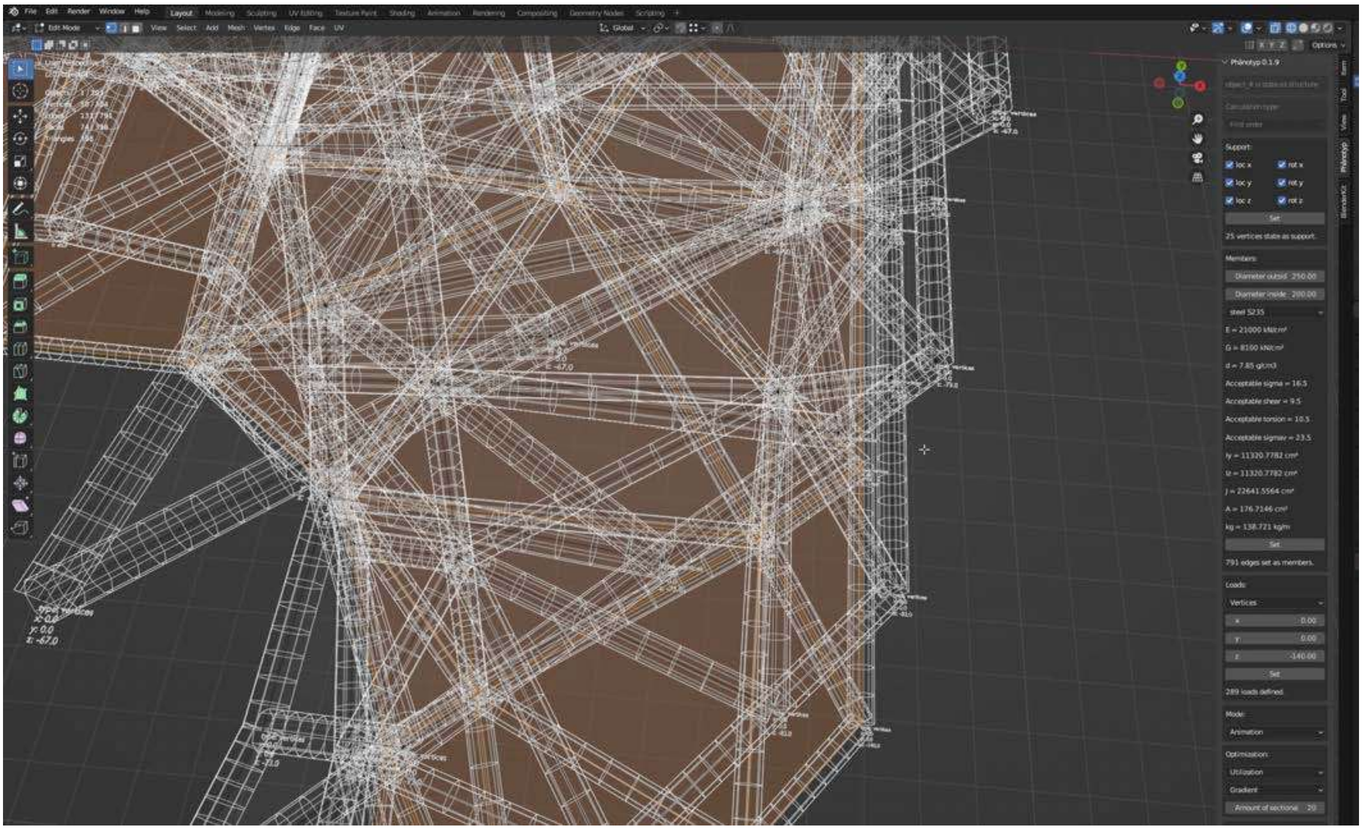
174: Phaenotyp Structural Model 1 Final Iteration - Complex Sectional Performance 5



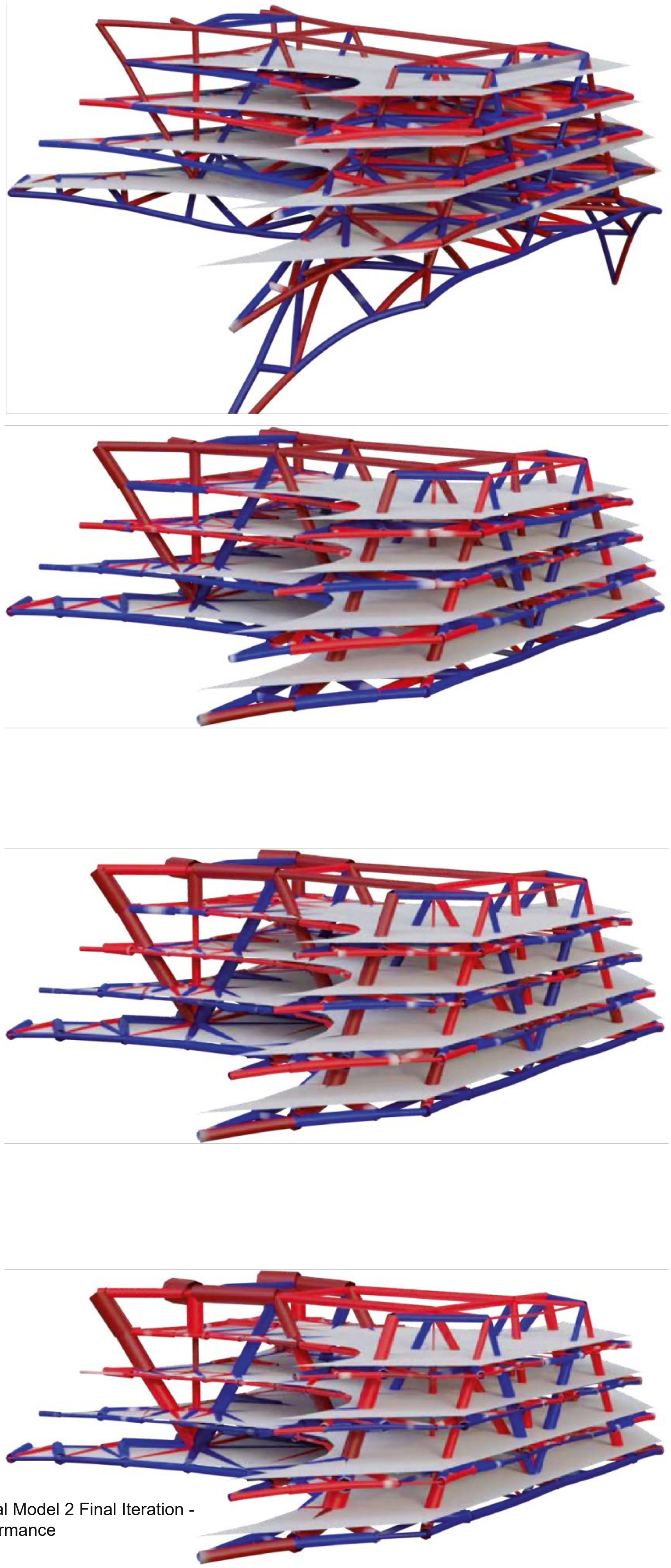


175: Phaenotyp Structural Model 2 Final Iteration - Base Shape and Support Vertices

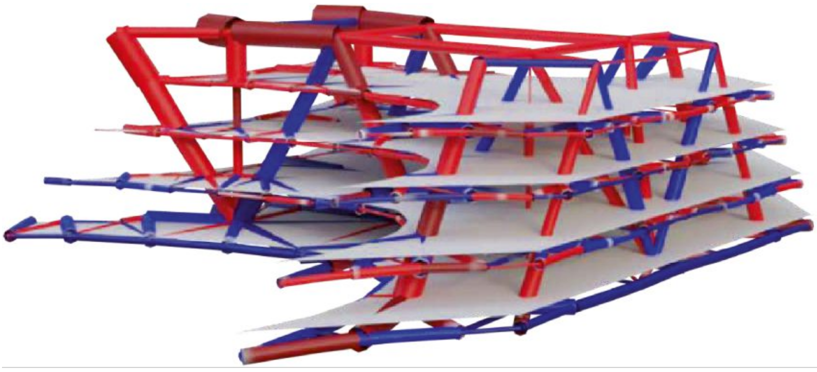


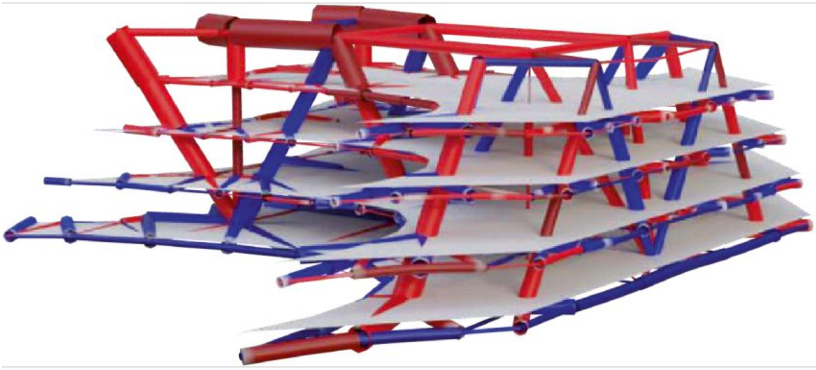


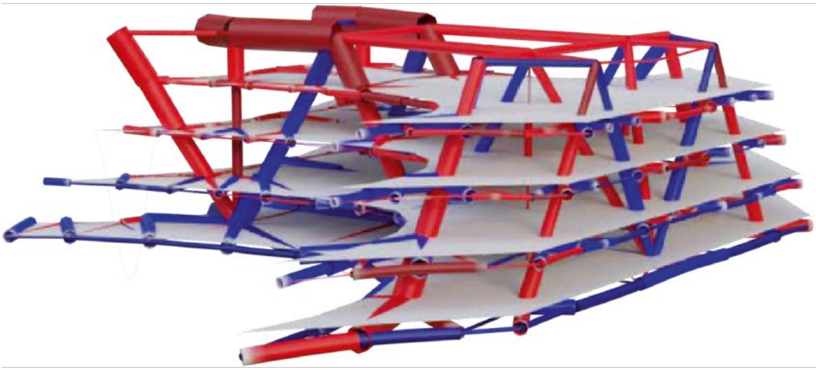
176: Phaenotyp Structural Model 2 Final Iteration - Crossection and Load definition

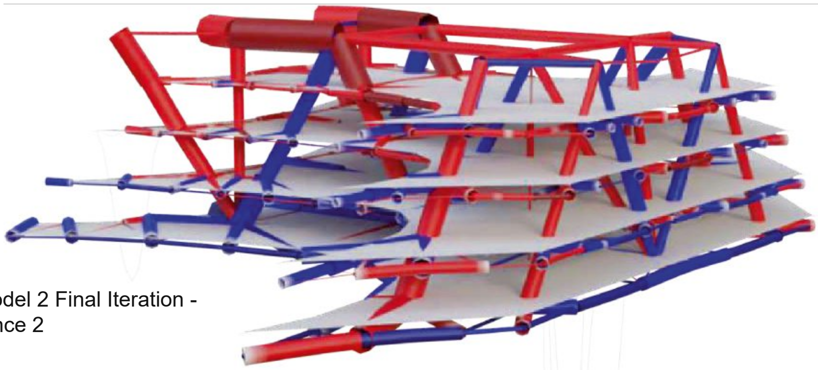


177: Phaenotyp Structural Model 2 Final Iteration -
Complex Sectional Performance

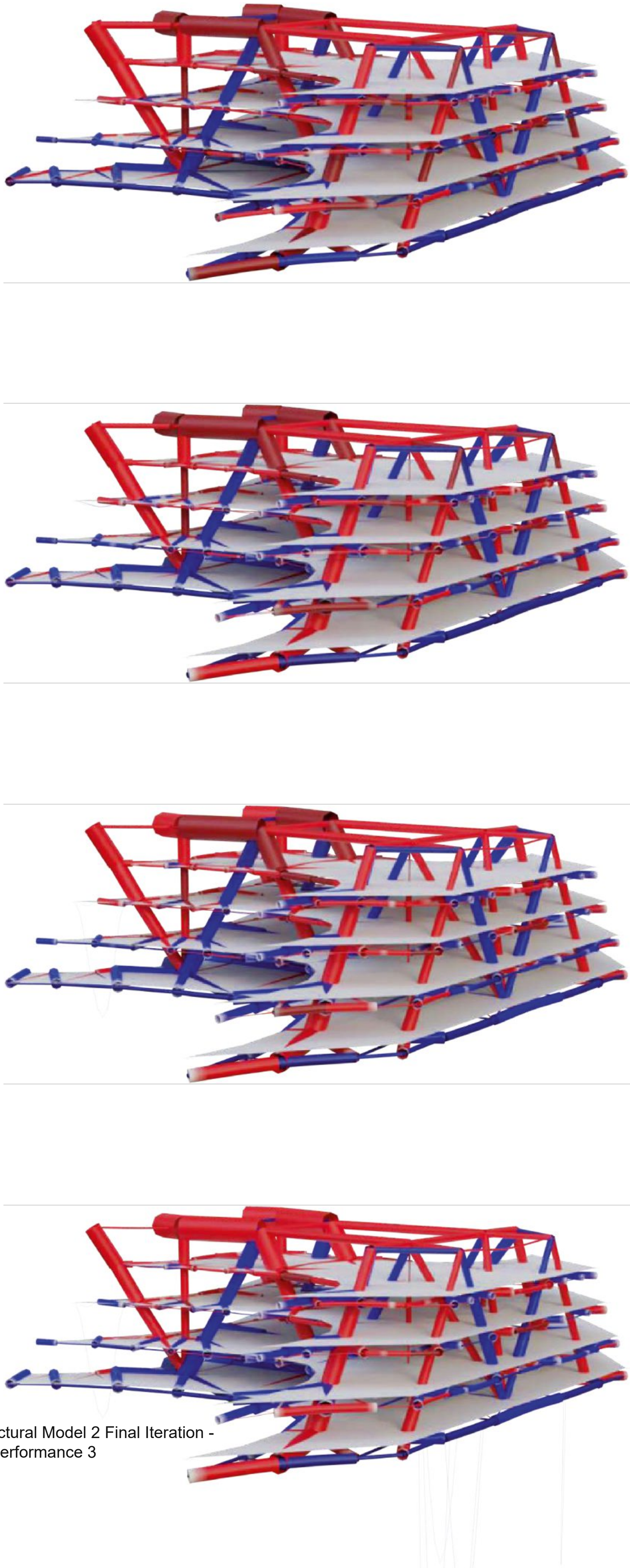




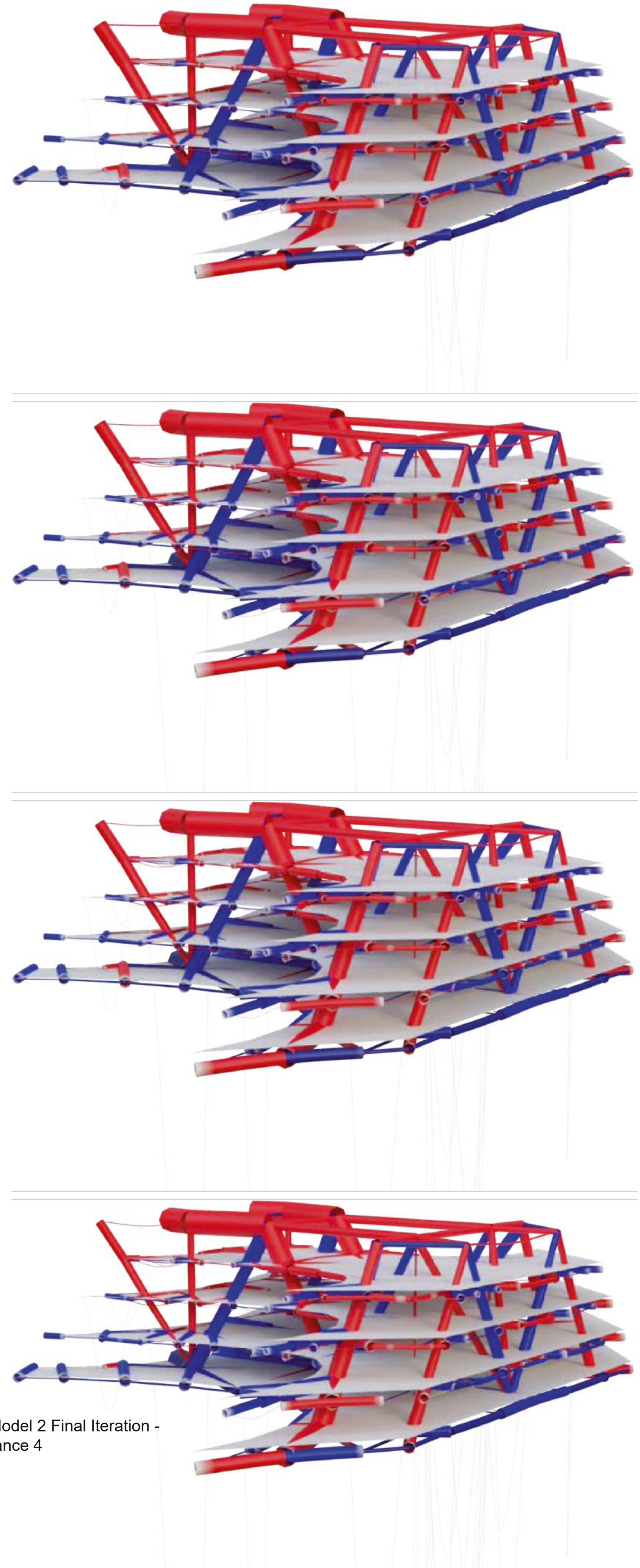




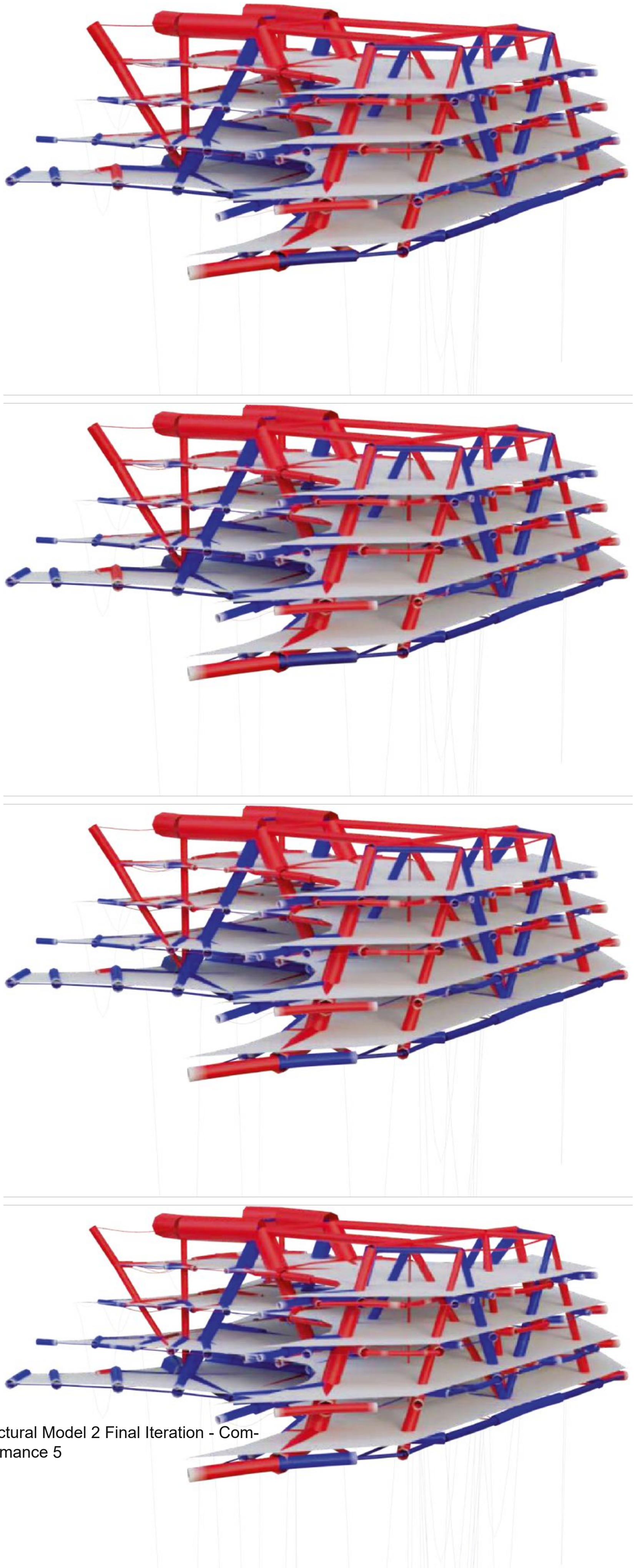
178: Phaenotyp Structural Model 2 Final Iteration - Complex Sectional Performance 2



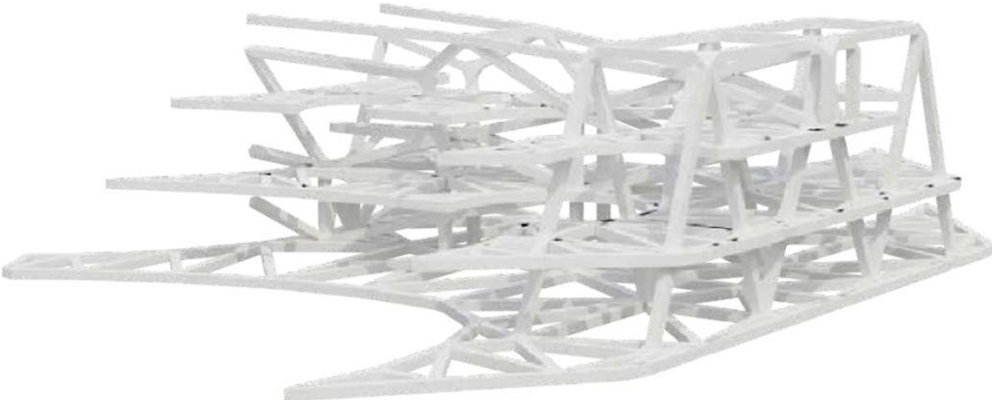
179: Phaenotyp Structural Model 2 Final Iteration -
Complex Sectional Performance 3

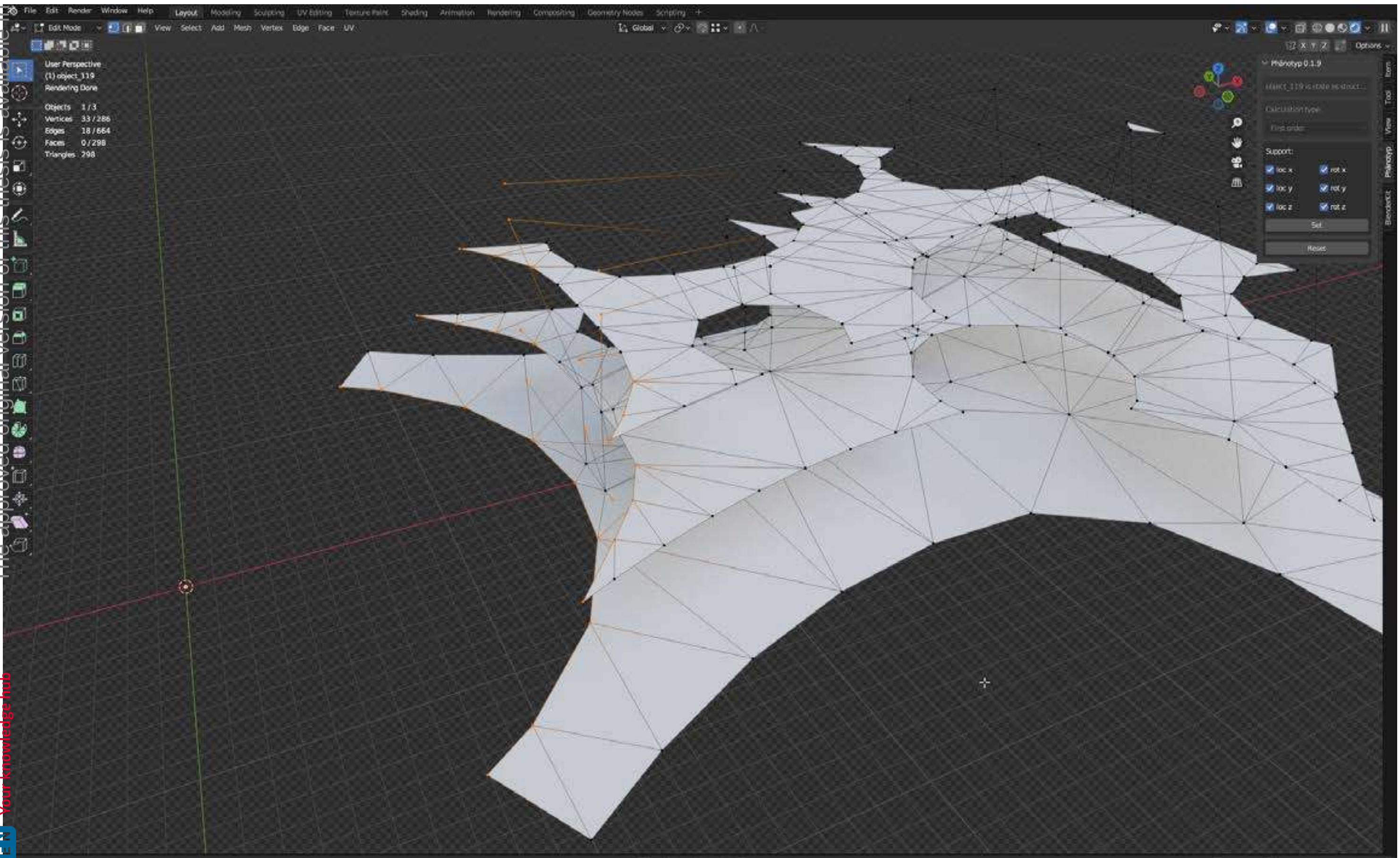


180: Phaenotyp Structural Model 2 Final Iteration -
Complex Sectional Performance 4

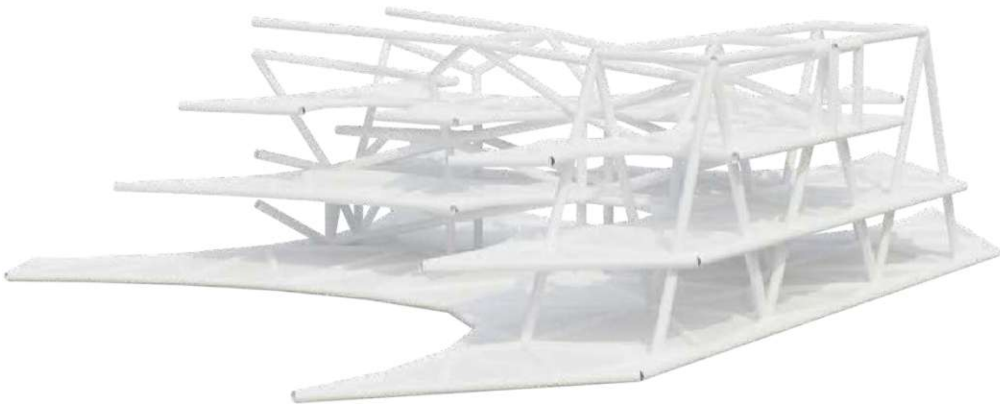


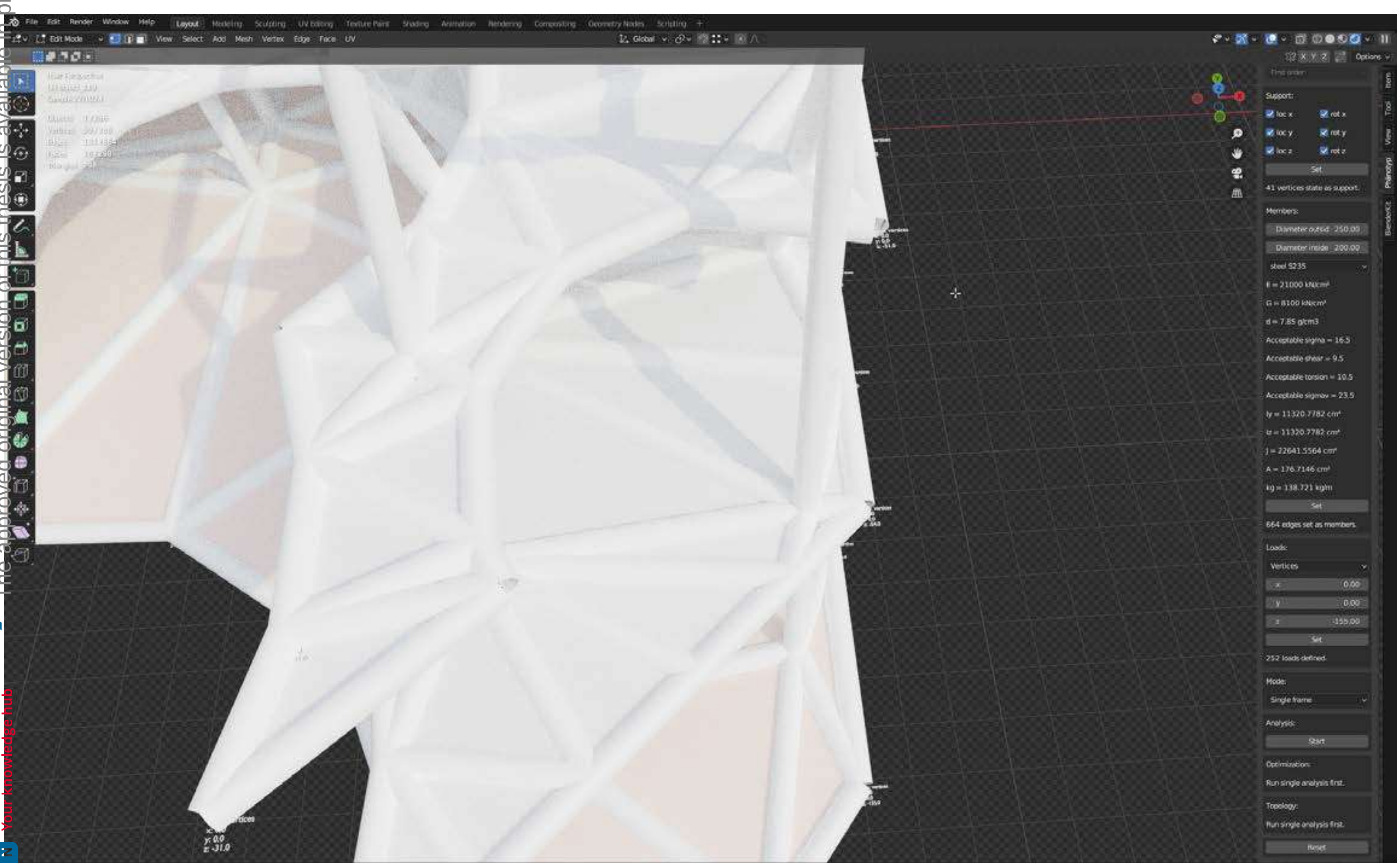
181: Phaenotyp Structural Model 2 Final Iteration - Complex Sectional Performance 5



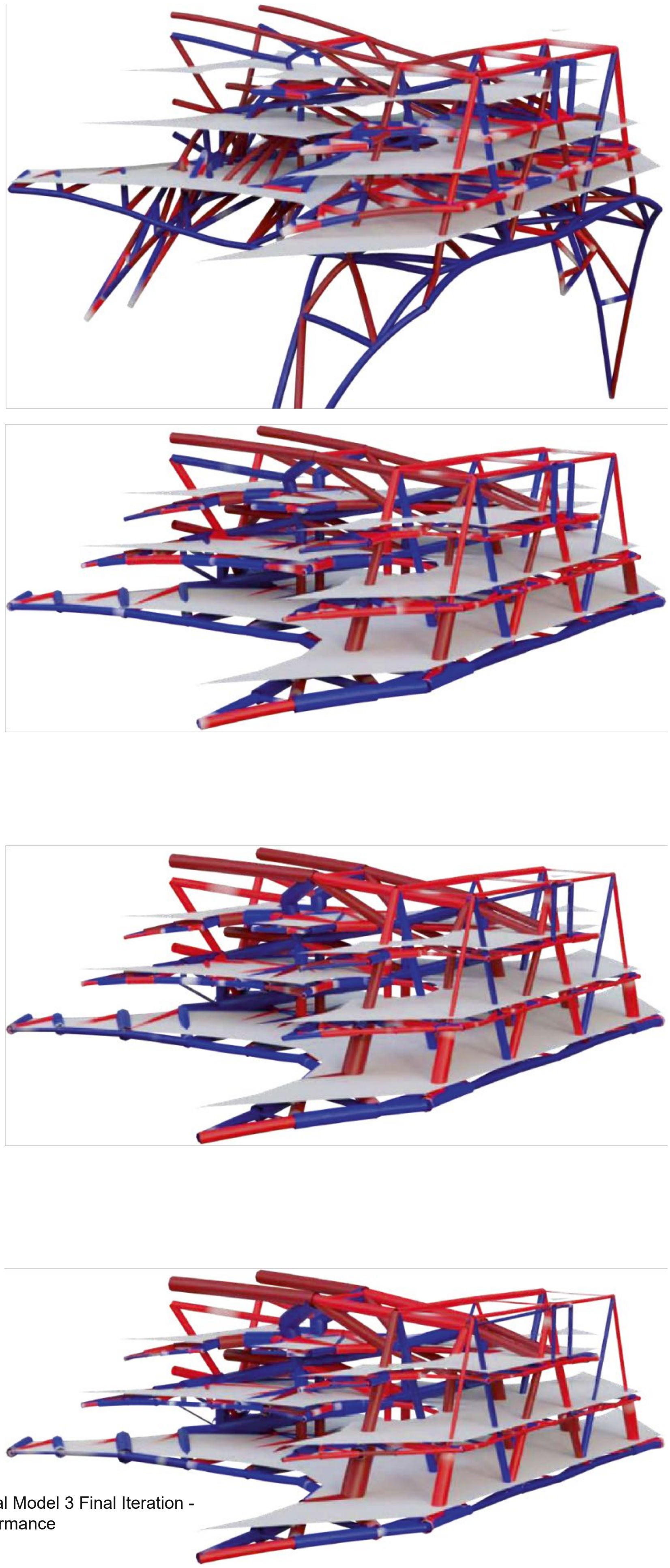


182: Phaenotyp Structural Model 3 Final Iteration - Base Shape and Support Vertices

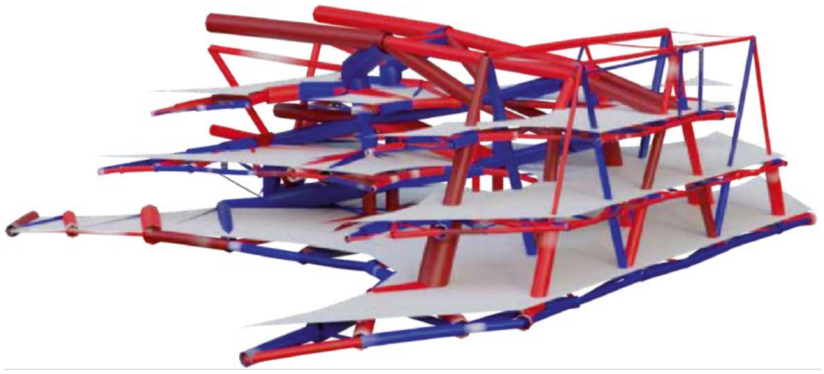


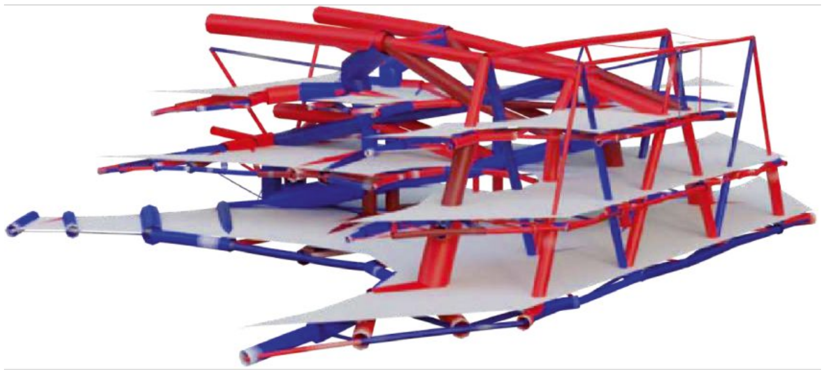


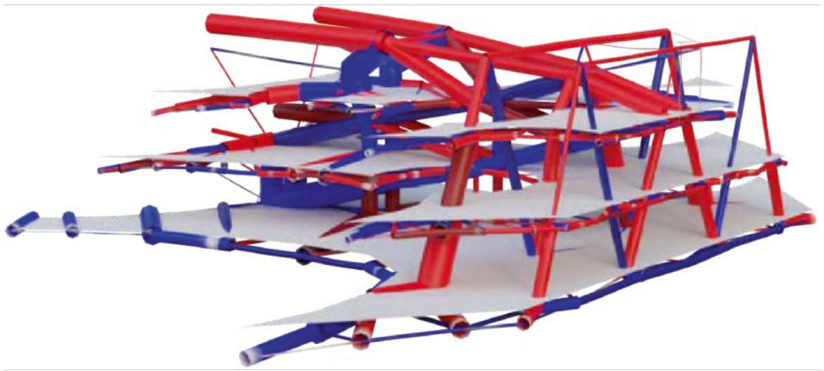
183: Phaenotyp Structural Model 3 Final Iteration - Crossection and Load definition

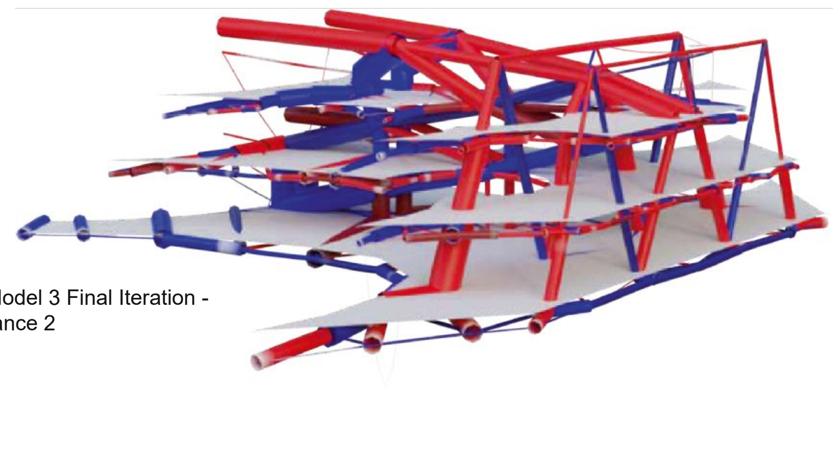


184: Phaenotyp Structural Model 3 Final Iteration -
Complex Sectional Performance

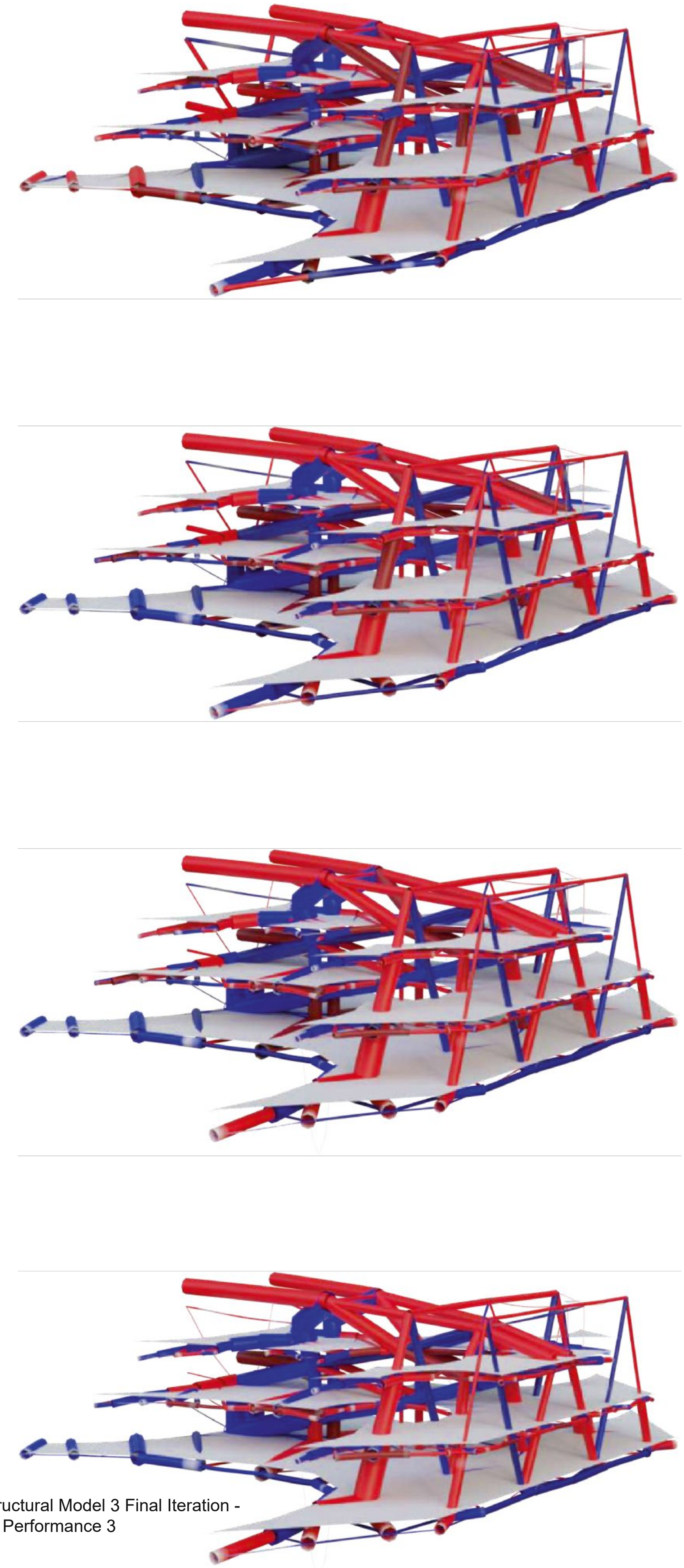




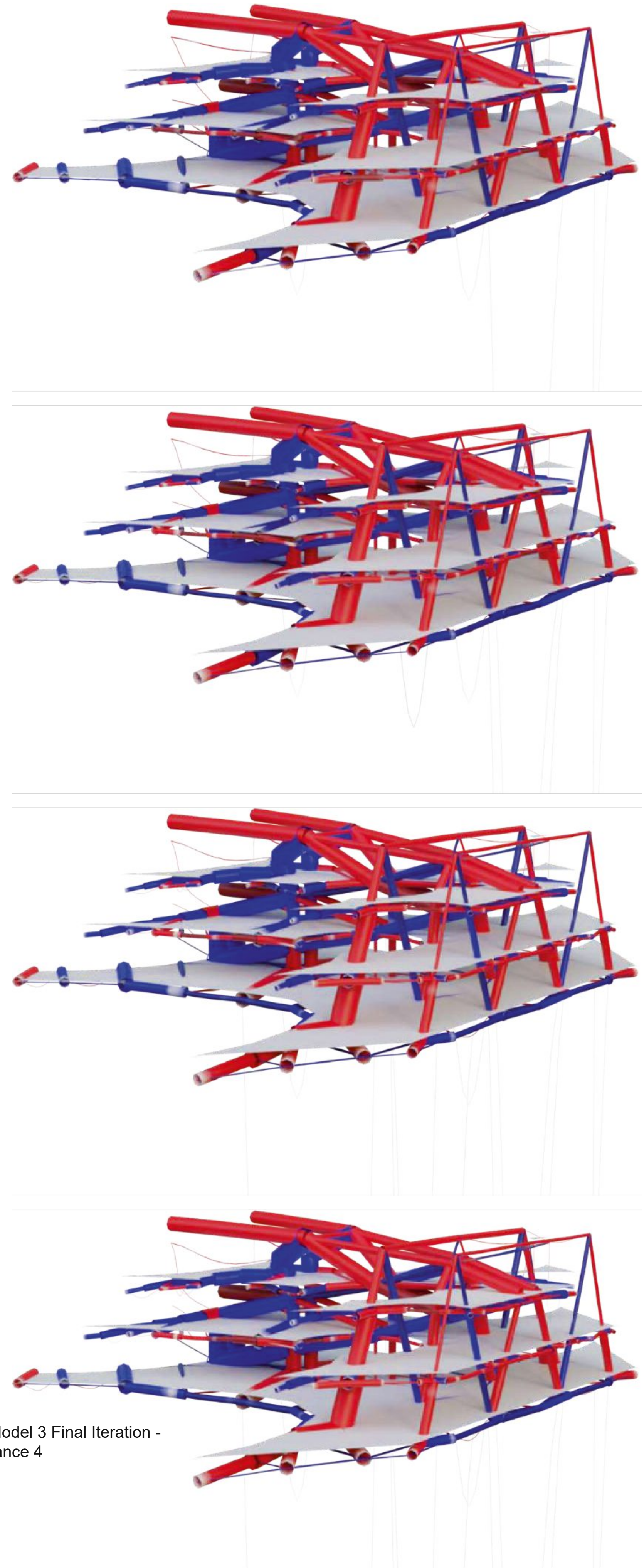




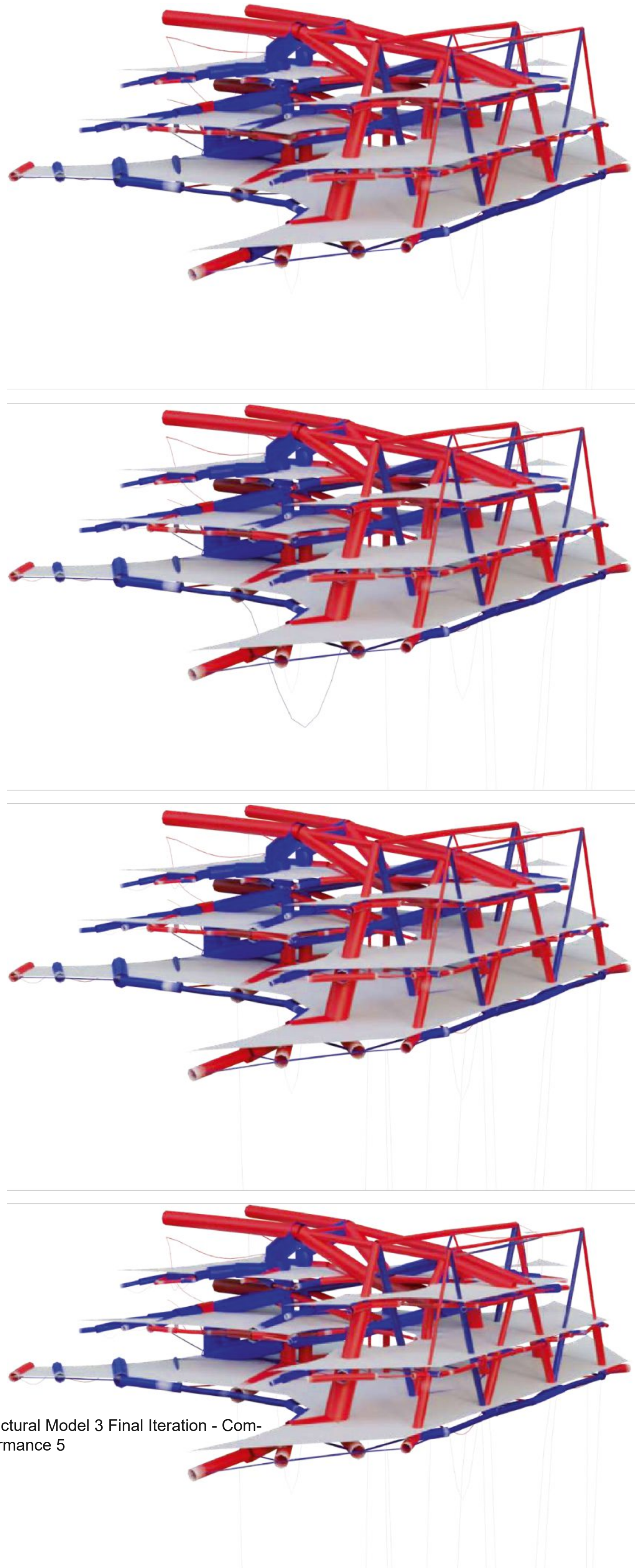
185: Phaenotyp Structural Model 3 Final Iteration -
Complex Sectional Performance 2



186: Phaenotyp Structural Model 3 Final Iteration -
Complex Sectional Performance 3



187: Phaenotyp Structural Model 3 Final Iteration -
Complex Sectional Performance 4



188: Phaenotyp Structural Model 3 Final Iteration - Complex Sectional Performance 5

7 Conclusion

In conclusion it can be said that this project while possibly hard to imagine in realisation for some might for others at the same time be the embodiment of a succesful step in the direction against many of the buring problems that keep vast parts of specially younger generations up at night. Climate change, social unjustice problems with urbanization strategies and urban planning all together. Many dificult problems are growing and few seam to have even a remote possiblitiy of solution in sight. This might be felt as depressing cause for resignation and despair but in this thesis is much rather used as an initial catalyst for the extensive exploration of multiple very promising technological advancements with the goal to implement some of these technologies into an architectural design. This final design composing the result of many formal and informal experimentations tries to represent a hopeful onsight to the challenges facing coming generations and manages to do so in multiple ways.
The exploration of technologies shows, that there are many very talented individuals working on niech developments to change the way energy is beeing produced and used in order to increase efficiency. While these small scale research efforts might not always recieve the attention they might deserve on the stage of public media and interest a clear tendency has been observed - occasionally these small projects manage to catch the attention of industry leading mega corporations providing cashflow as well as much needed manufacturing facilities in order to scale these startups into viable future-proof technologies that might be used on a mass scale some day. With a bit of luck this thesis can contribute to the visibility of small technological possibilities and initiate a growing interest in those willing and patient enough to follow through with the reading to also explore and study the technological advancements beyond those most prefelant in major media outlets. The variety of interesting advancements is seamingly infinite and could therefore have been studied and analysed a lot longer without coming to a conclusive ende - hinting only at the possibilities that are still hidden to be discovered and applied in an architectural context.
The demand for ongoing urbanization and the continued growth of metropolitan areas proof the need for sustainable vertical developments in order to limit the soil sealing demand arising from ever growing horizontaly expanding settlements. The demise in living quality once a certain threshold of lack of exposure to plants and natural environments is a clear argument to plan buildings in a more sustainable and organic way. Organic in this context meaning interacting with living organisms that are integral parts of a built environment and contribute in a substantial degree to the buildings internal

climate and air-quality conditions.
Touching on some of the issues related to current residential developments various types of living quarters have been proposed, these range from small scale units suitable for young adults, students or couples these units also idealy lend themselfs to a possible classification as social housing units or other cooperative living arrangements for example a scenario could be envisioned where people catering to the extensive plant live supported in the building would recieve substantial rent reductions if not free living accomodations all together in return for the work on the building. Similarly communal living arrangements could well be facilitated in the wide range of units of different sizes and orientations.
Though some difficulties arose from the strong dedication to variablity and adaptability in the buildings design these issues can all be interpreted as freedoms and opportunities for the future application of the design to any specific building site by any possible developer. The executed design provides ample opportunities for adaptation for example could material choices be reconsidered or altered over time, potentially giving different sites completely variable physical appearances of basically the same building typ. Further more the circulation concept through the various different modules can be adapted heavily and if not for the constraints in time and scope of exploration of this work it would have been possible to devise a multitude of additional floorplans and possible utilisations for the highrise. Programatic uses that could well have been implemented but have been left out due to time constraints include but are not limited to schools, larger commercial spaces like malls and or smaller shopping areas with individual small scale commercial usecases and shops for local crafts people to sell arts and crafts. A further alternative module design could incorporate vertical agricultural uses like proposed on Expo 2000 by MVRDV pushing along in the direction of a completely autonomous skyscraper settlement.

8 Source Index

1 United Nations (2019): World Urbanization Prospects.
The 2018 Revision, online under: https://population.un.org/wup/Publications/ --> https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf [25.5.2023].

2 Council on Tall Buildings and Urban Habitat (2023): Cities, online under: https://www.skyscrapercenter.com/cities [30.4.2023].

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184: Phaenotyp Structural Model 3 Final Iteration Complex Sectional Performance
By Martin Prömpers - in Blender 3.4 - Phaenotyp - 2023

185: Phaenotyp Structural Model 3 Final Iteration Complex Sectional Performance 2
By Martin Prömpers - in Blender 3.4 - Phaenotyp - 2023

186: Phaenotyp Structural Model 3 Final Iteration Complex Sectional Performance 3
By Martin Prömpers - in Blender 3.4 - Phaenotyp - 2023

187: Phaenotyp Structural Model 3 Final Iteration Complex Sectional Performance 4
By Martin Prömpers - in Blender 3.4 - Phaenotyp - 2023

188: Phaenotyp Structural Model 3 Final Iteration Complex Sectional Performance 5
By Martin Prömpers - in Blender 3.4 - Phaenotyp - 2023

10 Curriculum Vitae

Martin Prömpers

31.08.1993

Bonn, Deutschland

Education:

1999-2005 “International German School” Brussles

2005-2011 “Öffentliches Schottengymnasium der Benediktiner” Vienna

Oktober 2011-Oktober 2018: Bachelor Degree of Architecture at Technical University of Vienna

17.8.2013-31.5.2014: to semester studying abroad at Parsons the New School New York, NY

since October 2018: Master Degree Architectur at the Technical University of Vienna

Software Skills:

MS Office - Word Excel Power Point

AutoCad
Rhino 3D - Grasshopper
Blender

Adobe CC - Indesign Illustrator Photoshop Premier Pro After Effects

Languages:

German, English, Italian, Russian

Workexperiences:

2. Februar - 22. Februar 2013	BEHZADI + PARTNER ARCHITEKTEN BDA - Leipzig
2.Juni - 30. Juni 2014	Studio Libeskind - New York
1.July - 31. July 2015 1.August - 31. August 2016	WERKSTATT WIEN SPIEGELFELD, HOLNSTEINER + Co. - Vienna
November 2017 - November 2018	WESTPHAL JASPER GmbH. - Vienna
April - August 2019	Jasper Architects - Berlin
November 2019 - June 2022	Student Staff - Research/ Administration TU Vienna