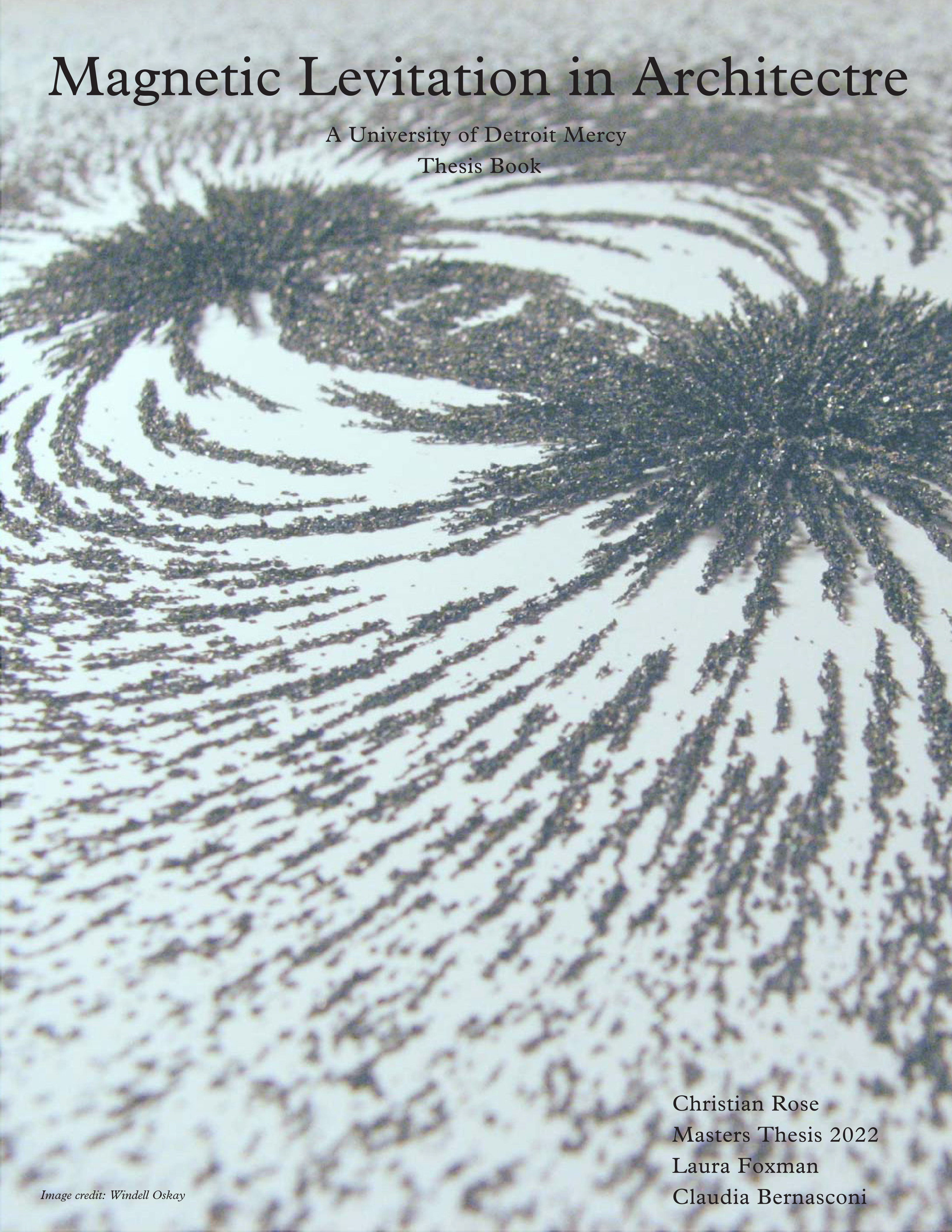

Magnetic Levitation in Architectre

A University of Detroit Mercy
Thesis Book

Christian Rose
Masters Thesis 2022
Laura Foxman
Claudia Bernasconi

Image credit: Windell Oskay

Table of Contents

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The Future and Architecture

Chapter: 1 Conceptual Reasoning

Introduction

Throughout history, architects and engineers have sought to find solutions to humanity's problems through the built environment, from basic shelters made from sticks and mud to multi-story residential towers of glass and steel or megalithic temples to venerate gods to aluminum framed industrial complexes producing everyday goods. Architecture will always be here, whether neanderthals built it in the countryside of ancient England, the siege engineers of Alexander the great, the high priests of ancient Egypt, or even studied professionals. All professions have or will influence architecture in some way, either directly or through the very nature of one's own profession itself. One can not fit a steel foundry into a small residential house; an industry professional is needed to find out how much space is necessary for said steel foundry. The same is true for every profession, from chicken farmers to rocket scientists; it is the architects' job in this current day and age to consolidate all the information from all different disciplines and peoples for whatever any given project requires and combine that information with their own expertise be that artistic, efficiency, both or everything in between. Keeping this in mind, a dialog between the magnetic sciences and architecture does not exist for these new experimental technologies. This book seeks to lay the groundwork for a guideline for architects' interaction with electromagnetic systems in the built environment.

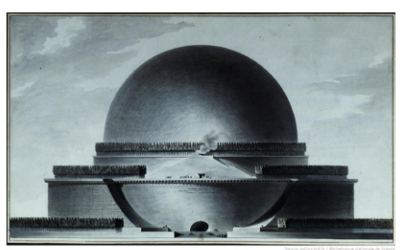


Image: (i1) Boullée's Cenotaph for Newton.

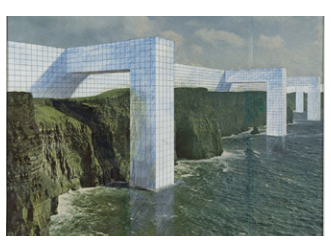


Image: (i2) Superstudio's Continuous Monument series.

Just as Structure varies depending on the function, the use of electromagnets to supplement building structure could be a great boon in particular architectural circumstances. Structure itself already varies with building type; a typical house uses a wood frame, and commercial facilities typically use a mixture of steel and concrete; in our current day and age, these passive systems hold up our build environment. As present-day technology stands, the subject that this book will focus on, magnetic and electromagnetic repulsion systems, is expensive and complex. Although the past few decades have seen a steep decrease in the prices in marital and efficiency of production, the procedures involved are still far too complicated and expensive for everyday use in the common realm.

Technologies discussed in this book will be through the lens of the future where it is assumed magnetic materials, production, and power are less expensive and are worth investing into. A structure even in the future using this magnetic levitation technology might still be considered a novelty or only to be used in certain circumstances. It is those very circumstances that this book will look at and evaluate the various uses of electromagnetic levitation in architecture.

By creating several design charrettes at different scales and using the magnetic technology in different ways for each typology and scale, we can look at how it can affect building occupation and the limits of what this technology can do. These theoretical uses are akin to Etienne-Louis Boullée's conceptual Cenotaph for Newton (i1) or Super-studio's Continuous Monument series (i2), which pushed materiality at the time to and even past its known limits in their designs and past the boundaries of economic feasibility.

References: (i1) Gallica.bnf.fr / Bibliotheque nationale de France, (i2) https://www.moma.org/collection/works/934

Magnetic property's

Magnets, magnetics, electromagnets, and magnetic fields are terms thrown around in this book, so there will be a quick overview and reminder from your 8th-grade science class standpoint of magnets and the basics of how they work.

Magnets are a material that produces a magnetic field, an inviable force extending from and rapping around the magnetic object, moving a current of electrons from the north to south poles of the magnets, which are based at opposite ends. Coincidentally when two opposite poles come near each other, the magnets attract and quickly pull together. Conversely, when two of the same poles come near, they repeal. Electromagnets behave the same but only when a current is applied.

Magnets are typically known for their attractive properties; as mentioned above, they can repeal; this part of the magnetic force is most intriguing. An invisible force that can pass through none magnetic material. This book will focus on the potentials of electromagnetic technologies, the past, present, and future of the technology, the risks and impacts of using the technology and how to overcome and protect against those risks.

A Burgeoning Technology

From the early Chinese compass in the fourth century BC (i3) to modern smartphone magnets (i4) and electromagnets that have been around, needless to say, for a long time. For example, the electrical generator is a staple in the power production of our modern world. Recent advancements in magnetic technologies like the room temperature superconductors breakthroughs by Cambridge University scientists, nuclear power production revolutions such as the many small modal nuclear reactors concepts (f1) from GM and Rolls Royce, and power storages like new Supercapacitors which can hold massive amounts of power for long periods. These recent breakthroughs have allowed scientists, engineers, and architects alike to start thinking about what kind of implications this kind of technology might have on a different scale.

As Electromagnetic systems become more common in everyday products, some architects have already started implementing and conceptualizing projects involving them or even using technologies that use electromagnets in their structures. Later in the book, we will look at several small-scale examples of percent-day objects that current-day architects could run into.

Image: (i3) Early Chinese Compass

Image: (i4) Inside of a modern day smartphone. Note the copper colored wireless charging component, which basically is an electromagnet.

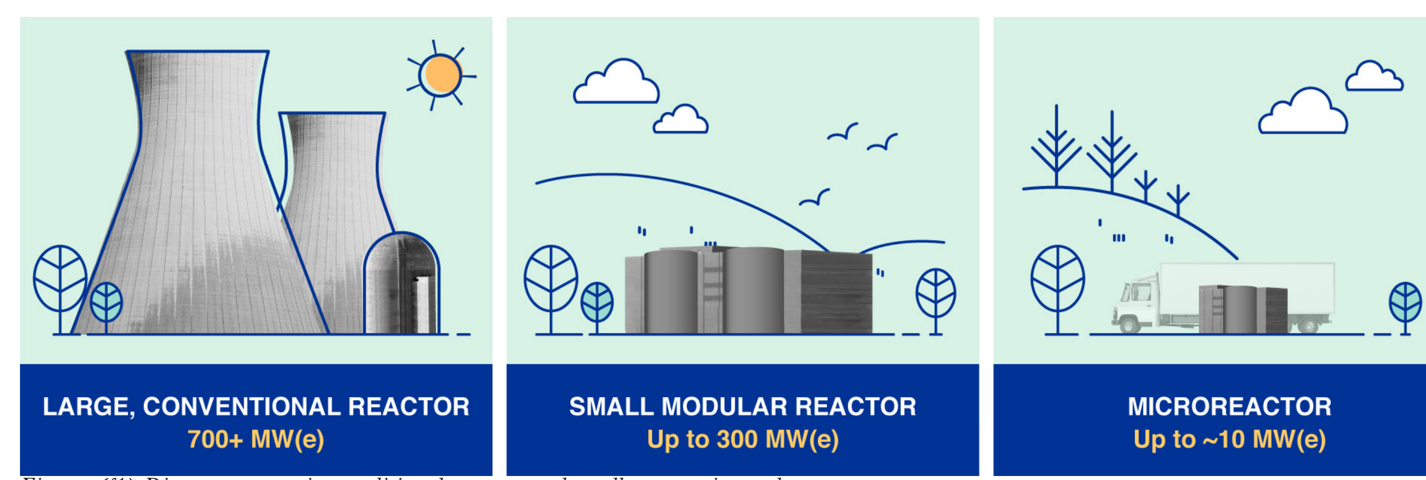


Figure: (f1) Diagram comparing traditional reactors and small reactor size and power output.

References: (i3) Wikimedia Commons, (i4) ifixit, (f1) A. Vargas/IAEA

I

The Future and Architecture

Chapter: 2 The Existence of Variety

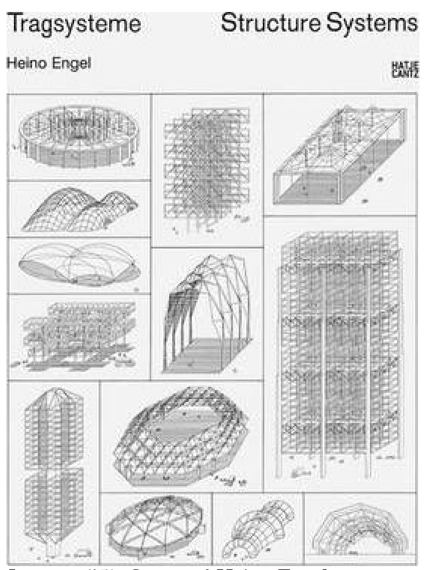


Image: (i5) Cover of Heino Engel Tragsysteme Structure systems

An Argument for Structure is made by Heino Engel in Tragsysteme Structure Systems (i5); in his book, he states, "Without Structure material forms cannot be preserved, and without perseverance of form, the very destination of the form object cannot assert itself." Arguing structure is paramount to any architectural design. This thinking can be applied to technologies. In the book, Engel states that most buildings fall under two categories. Firstly buildings that cover up their structure; secondly, buildings that flaunt their structure as part of the design. Ultimately a building's space is limited by the structural engineers or architects ability, due to specialization, which Engel argues is essential to the way we do architecture today. This, however, doesn't even mention the dozen other arrays of expertise that, throughout the decades, have been moved into a more specialized role. In general, Electrical, HVAC, plumbing, and construction are just the basics; there are lawyers, environmental experts, Geologists, and so much more that all contribute to architecture. Knowing this, it is not impossible to think that in our ever technologically advancing world that other areas of expertise will eventually get involved and, in fact, already have.

Given the coming space-age, architects will have to construct within environments that require large pieces of technological, power, protection, and environmental controls and systems. This kind of thinking can also be applied to climate change effects and systems that deal with flooding and increased weather phenomena that might be implemented in buildings in the near future.

In Engel's Book he states the following that can closely be applied to structural electromagnetic systems technologies for architecture,

"in architecture structure assumes a fundamental part

- Structure is primarily and solitary instrumental for generating form and space in architecture. Owing to this function, structure becomes the essential means for shaping the material environment of man.

- Structure relies on the discipline exerted by the laws of natural sciences. Consequently, amongst the formative forces of architectural design, structural ranks as an absolute norm.

- Structure in its relationship to architectural form nevertheless commands an infinite scope for interpretation. Structure can completely be hidden by the building form; it can as well become the building form itself, architecture.

- Structure personifies the creative intent of the designer to unify form, material and forces. Structure thus presents an aesthetic, inventive medium for both shaping and expressing buildings."

Just like Engel stated on structure architecture and technology, and for our purposes, electromagnetic structural systems can also, on a fundamental level, be unique and even a necessary part of any project.

References: (i5) Heino Engel Tragsysteme Structure systems,

"Structures determine buildings in fundamental ways: their origination, their being, their consequence. Thus, developing structure concepts, i.e. basic structural design, is an integral component of genuine architectural design. Hence, the prevalent differentiation of structural design from architectural design - as to their objectives, their procedures, their ranking and, for that matter, as to their performers - is unfounded and in contradiction to cause and idea of architecture.

The differentiation of architectural design and structural design has to be dissolved."
-Engel

While the debate of what architects should or shouldn't be focused on rages on, it is inevitable that specialization will take its toll in the coming decades, perhaps even fully separating the fields of architecture and civil engineering even further and allowing even more disciplines inside of architecture allowing entire schools to divulge into commercial, residential, industrial, and maybe even farther than that. We already see such examples with certain groups proficient in one area, such as specialists in hospital design or interior offices. The technicality of structure and other fields in noted by Heino Engel, especially by the architect himself, when considering the vast amount of other areas that the architect is supposed to have knowledge of. These thoughts can also be applied to building and structural typology. With millions of different needs, billions of structures are built every year, and every one of them serves a different people and function in every sense. The architect, subservient to the client, whether one, multiple, or themselves, always has to work with in a framework of sorts set forth by the client. While the debate of what architects should or shouldn't be focused on rages on, it is inevitable that specialization will take its toll in the coming decades, perhaps even fully separating the fields of architecture and civil engineering even further and allowing even more disciplines inside of This framework involves the primary goal of the project as well as any and all conditions set by the client but also involves the architect's learned own style, which includes spacial layout, defined by structure, material suggestions to the client, as well as context, and understanding of the social, political, and environmental surroundings, both in the physical and cultural sense.

While some architects don't do everything listed above, all architects make sure the structure can withstand the environment in which it is built in.

Seismic activity & History

Since the dawn of civilization, man has sought to build structures that resist nature and her forces. Earth quacks, in particular, have been the doom of many a design, and as far back as ancient Japan(*i6*), humanity has had countermeasures built into the structure. In the present however this is strongly needed as we build taller and more densely populated buildings, and several anti-seismic systems have been developed over the years.

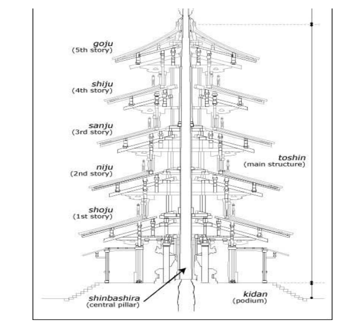


Image: (i6) Japaness anti-seismic design.

Currently, two main systems that are used to counteract seismic activity: active control systems, semi-active systems, and passive systems, passive systems like those used in ancient China and Japan use the passive structure system itself to counter seismic loads, usually taking inspiration from nature, such as how trees withstand seismic activity.

On the other hand, active systems must always be powered; these systems, like the Active Tendon system or the AMD (Active Mass Dampeners), adjust themselves using computers to compensate during a quake constantly(*i7*).

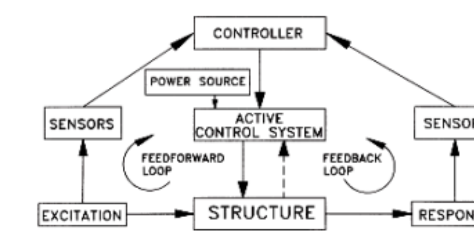


Image: (i7) Computer process for seismic activity

These systems are essential to look at when trying to determine the potential plausibility of applying technology to the structure of a building.

References: (i6) Seismic Design and Construction of a Traditional Timber-Made Five Storied Pagoda by Applying Coupled Vibration Control, (i7) #13 in References

Image: (i8) Maglev Train in China.

While the United States train scene is a in a sorry state, many other countries have efficient rail networks and even high-speed networks; these rail networks usually work off of a standard rail gauge that is expanded when needed. However, some countries have been looking into the plausibility of adding a new type of track and creating a new magnetically propelled network.

The Maglev Train

Maglevs trains*(i8)* or magnetic levitation trains are commonly known today as the fasts commercial trains in the world, able to reach upwards of 375 MPH having known operations in Japan and China, Maglevs have a history as far back as to 1908, where a Cleveland mayor built a scale model in his basement. From then on, many patents were filed over the years, such as Herman Kempers German patents in 1937 and 1941, G. R. Polgreens 1959 US Patent. Then in Japan in 1969, stretching through the 1980s, culminating in Japan's current High-speed rail network. This success spread to other countries, including Germany, China, and South Korea, which operate high-speed rail lines.

However, while sounding like a brake through technology, maglevs are incredibly inefficient, consume vast amounts of power, and only operate at average train speeds; this is not the only issue, as a new specialty track also has to be built—all this culminates in a vanity project that is economically environmentally damaging.

Alternatively to architecture, science has entire fields dedicated to solving various natural and man-made quandaries, from the universe's great mysteries to the global crisis of climate change. These involve many experiments, some seemingly unrelated to anything but nonetheless important.

In the Name of Science.

Conseil européen pour la recherche nucléaire CERN or the European Organization for Nuclear Research, established in 1959 by 12 countries the laboratory studies high energy physics and subatomic particles. The Large Hadron Collider LHC is a particle accelerator finished in 2008 and is receiving constant upgrades.1

LHC at CERN *(i10)*, as stated above, is a particle accelerator that uses massive electromagnets to accelerate subatomic particles along a magnetic track into a target; by doing this, the particle is dismantled violently and leaves behind various debris, which is studied and used in multiple experiments. The electromagnets in the LHC are among the most advanced in the world, being able to accelerate a particle material to near the speed of light along its 17-mile diameter track.

Particle Accelerators like the one at CERN have been using this frictionless environment that magnets can provide for decades and have themselves provided the best examples of what kind of support machinery would be required for high-powered electromagnetic systems that will look at later in the book.

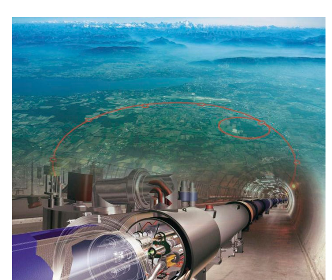


Image: (i10) The LHC's extensive 17 mile magnetic track.

References: (a) (i8) China/Barcroft Media/Getty Images, (i10) CERN/Maximlien Brice

Magnets, with their repulsive properties, have been used in some unique ways on the inside of buildings. Some high-end furniture makers and architects have come up with several high-end designs that can be purchased. While these pieces are incredibly pricey, they represent an early benchmark for technological progression. The Float table *(i11)* is a custom low standing table that uses a system of magnets and guild wires to levitate wood veneered cubes that hide the magnets inside themselves.

Designed in a warehouse in New York, customers can order her custom furniture from an online catalog. Each piece will be handcrafted to order and functions as a stunning centerpiece for any room.

Also offered by the same person is the Float shelf, functionally the same but mountable on a wall.

Another product for home use that can currently be purchased is the Floating speaker. Several variants of a floating speaker exist and provide an excellent sound experience. In a standard speaker, some sound waves are lost and transferred to the surface of whatever the speaker is sitting on, but zero sound waves are lost in this manner on floating speakers.

The Float Bed *(i9)* is a multi million dollar levitating bed that comes with a room design as the magnetic repulsion engines are hidden below them.

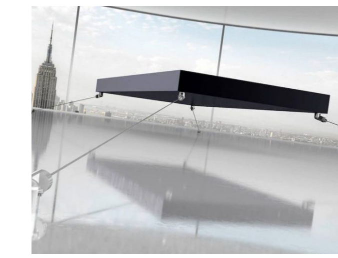


Image: (i9) Florating Bed

The Hendo hover Board uses a Hover engine to glide above a predetermined copper-coated surface. The machine was designed by architect &@$^* initially to float houses above terrain in California as an anti-seismic measure was sold to Hendo hover to make this unique toy.

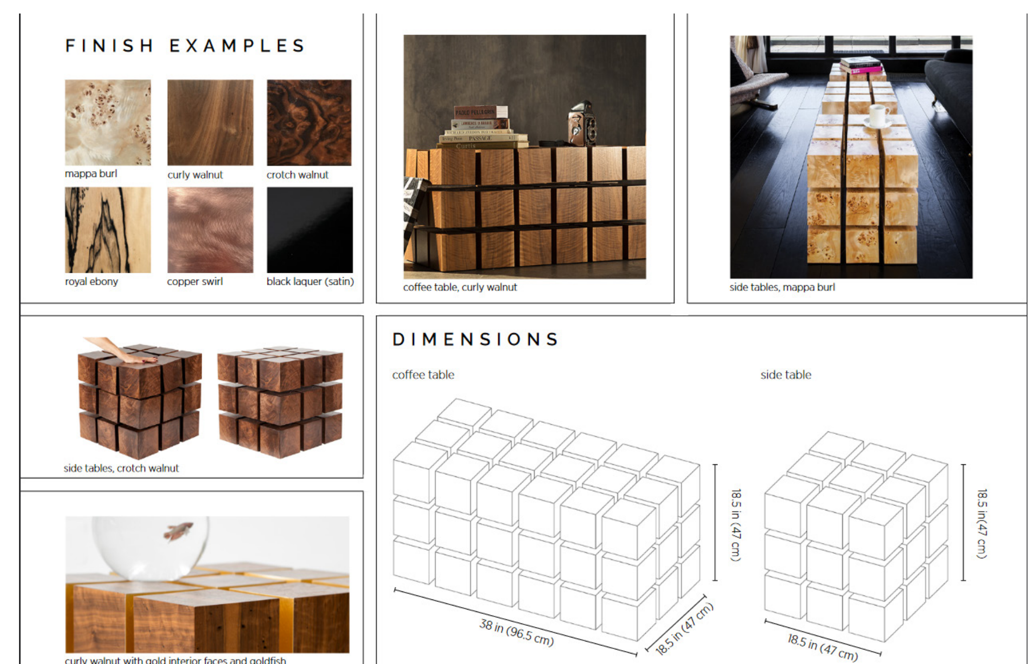


Image: (i11) Float Table

References: (a) (i9) http://www.universearchitecture.com/projects/floating-bed, (i11) https://rockpaperrobot.com/products/float-table-1

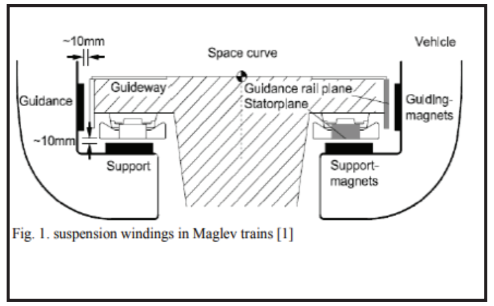
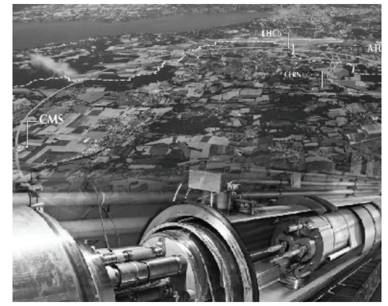
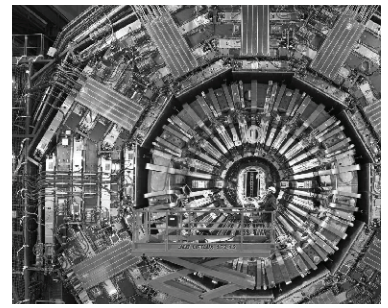
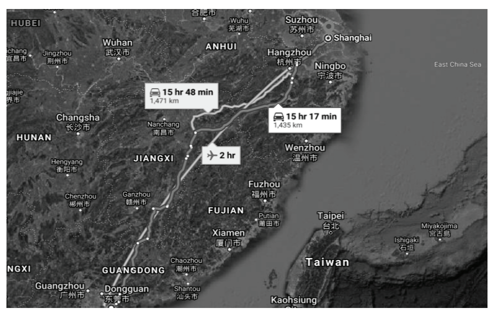
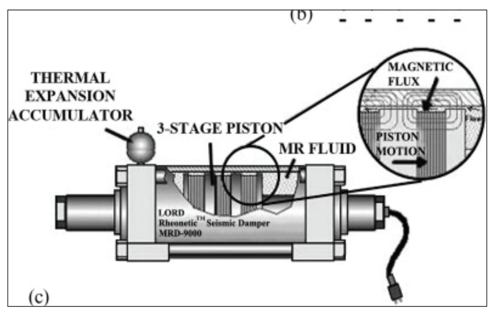


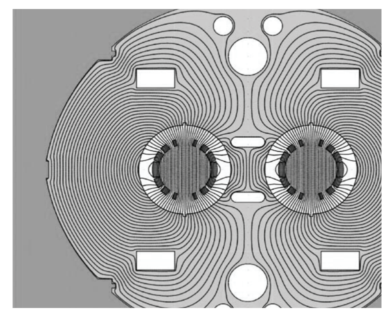
Fig. 1. suspension windings in Maglev trains [1]











QUNGDAO MAGLEV TRAIN

LOCATION / DATE
Qingdao, China 2019

DESIGNER
CRRC Qingdao Sifang Rolling Stock
Research Institute

INNOVATION / DETAILS
Operating at 600km/hr (373mph) the train can cover the distance between South China's Shenzhen to Shanghai in about 2.5 hours.

TODS BUILDING

LOCATION / DATE
Tokyo, Japan 2004

DESIGNER
Toyo Ito

INNOVATION / DETAILS
The project placed seismic isolation devices in its foundation to avoid cracking of its 30 cm thick reinforced concrete Structural wall facade.

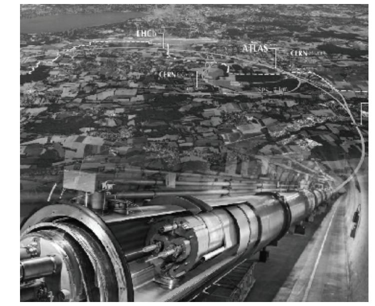
LCH AT CERN

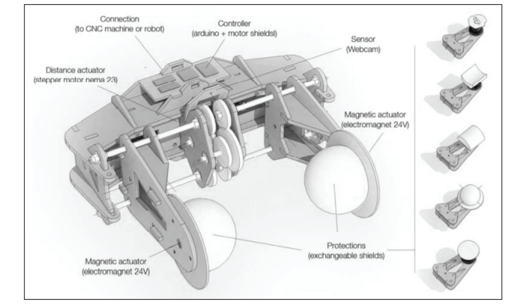
LOCATION / DATE
France and Switzerland establ
1952

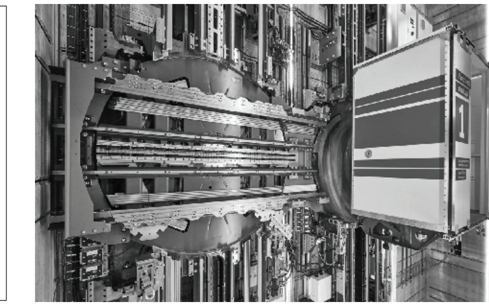
DESIGNER
Lead by Lucio Rossi
and many others

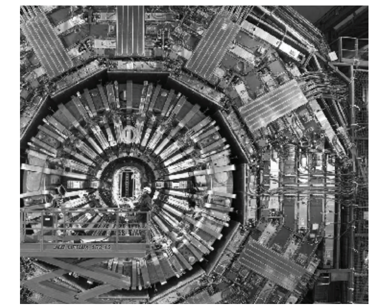
INNOVATION / DETAILS
The Large Hadron Collider(LHC
5 plus mile diameter wide para
accelerator used by the scien
community at CERN to solve s
the universes greatest proble

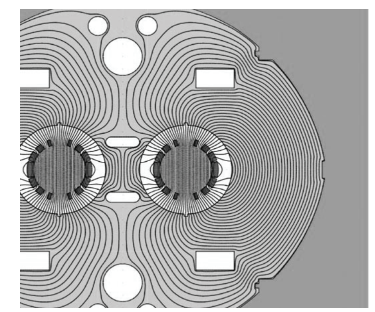
The Practical











ERN

/ DATE
l Switzerland established in

cio Rossi
others

)N / DETAILS
Hadron Collider(LHC) is a
diameter wide parasitical
r used by the scientific
at CERN to solve some of
ses greatest problems.

MAGNETIC ARCHITECTURE

LOCATION / DATE
Barcelona, Spain 2020

DESIGNER
Dubor Alexandre
Diaz Gabriel-Bello

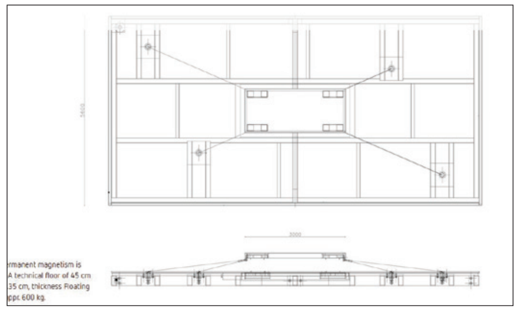
INNOVATION / DETAILS
A study looking at the potentials of linking the collection of material data with mechanic control of generative design in relation to digital fabrication within architecture.

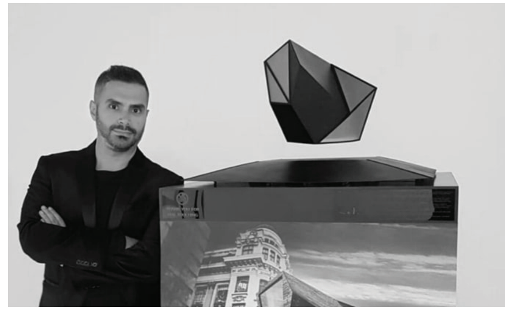
MULTI ELEVATOR

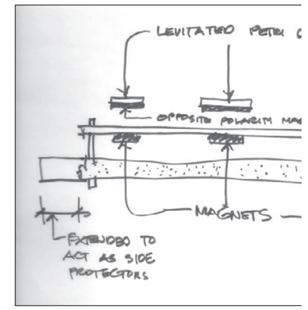
LOCATION / DATE
Germany 2022

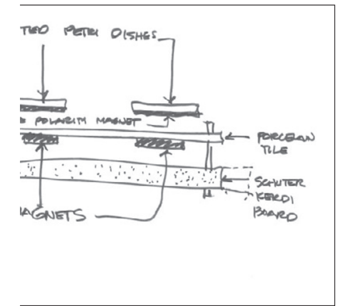
DESIGNER
MULTI

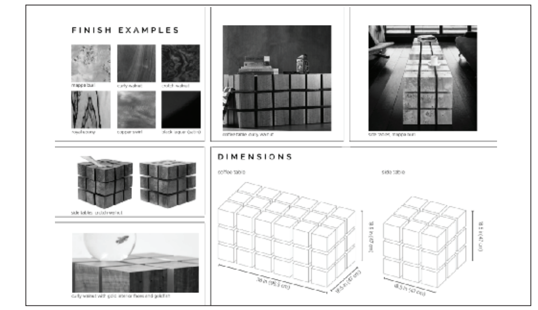
INNOVATION / DETAILS
This yet to be used system uses a series of electromagnetic tracks and switches to create an elevator that can travel continuously both horizontally and vertically with multiple car's running on the same track.

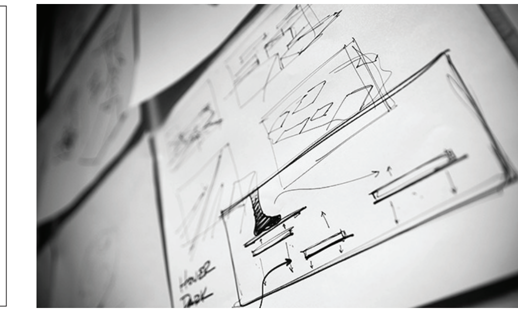


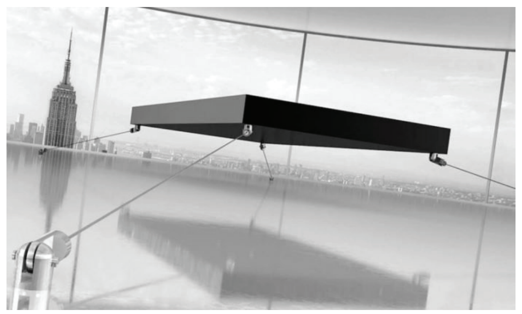


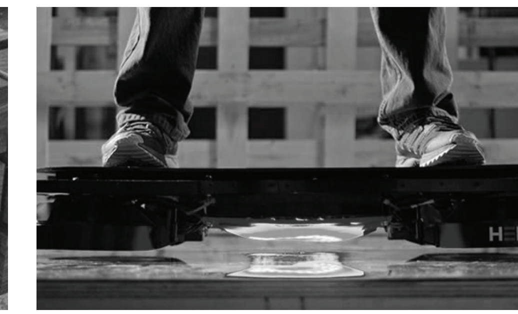


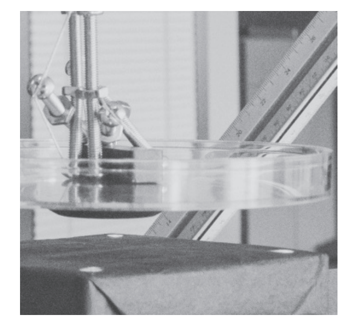


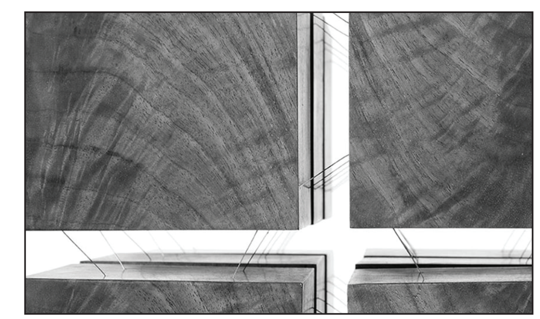












FLOATING BED

LOCATION / DATE
Availability Online : Now; $1.5 million

DESIGNER
Janjaap Ruijssenaars

INNOVATION / DETAILS
2001: A Space Odyssey' was a an inspiration for the Floating Bed which floats approximately 1'-2" off the floor and can hold more then 1320 lbs

RISING OASES

LOCATION / DATE
Kachaamy has been working on this project for over 13 years.

DESIGNER
Georges Kachaamy

INNOVATION / DETAILS
Using ultra lightweight 3D printed parts over the past 5 years Kachaamy has made dozens of models using multiple different kinds of magnetic technology.

MAGNETIC LEVITAT

LOCATION / DATE
Philippines 2016-202

DESIGNER
Lira Luis

INNOVATION / DETAIL
Experimenting on the
years Lira is dedicatec
though practical mode

EVITATION

TE
L6-2020

DETAILS
on the concept for 4
dicated to figuring out
al modeling.

FLOAT TABLE

LOCATION / DATE
Brooklyn currently available $10,000

DESIGNER
Jessica Banks from RockPaperRobot

INNOVATION / DETAILS
The magnetized cubes veneered in wood levitate with respect to one another and the repelling cubes are held in equilibrium by a system of tensile steel cables.

HENDO HOVER BOARD

LOCATION / DATE
California 2013

DESIGNER
Greg Henderson from ArxPax

INNOVATION / DETAILS
Initially developed as an anti earthquake system for buildings the consequently developed hover engine was rethought into the concept of the hover board.

The Excessive

I

The Future and Architecture

Chapter: 3 Futurism and the Future

Futurism and Optimism

Futurists are at the forefront of thought for implementing new technologies and tend to have an optimistic approach to the future of humanity. That being said, as architects that exist in the now, we must address the crucial issues of the day, such as climate change and economic and cultural inequality; this section will focus on both.

Many people look at the world today and despair, climate change and its politics being a significant factor in that outlook. Varies companies blamed for most of the damage to the climate are, however, the source and reason for the existence of the modern world without the vast amounts of money spent on research and development. Without this R and D, our modern world doesn't exist, yet massive anti-corporate and anti-capitalist talks abound in the West. While it is essential to hold a balanced and understanding worldview, it is not impossible to come to some agreement when looking at all the seemingly vanity-driven projects.

Precedent

Image: (i12) Rising Oasis

For the last 20 years, architects and scientists alike have dedicated their downtime to experimenting with the idea of magnetic levitation. Over those years, many schemes have been thought up depicting many different typologies and structural system implementation.

Dubai 2050, an annual futurist expo held in Dubai, is a hotbed for visionary architects looking to wow clients with fantastical designs. With the advent of more and more magnetic technologies in our daily lives, several entries appeared for the recent events displays.

Image: (i13) Lira Luis w/ Magnetic model

References: (a) (i12) https://www.dubaidesignweek.ae/programme/2019/levitate/ Georges Kachaamy,
(i13) Ksju Kami. Rendering: ALLL. Sketch: Lira Luis

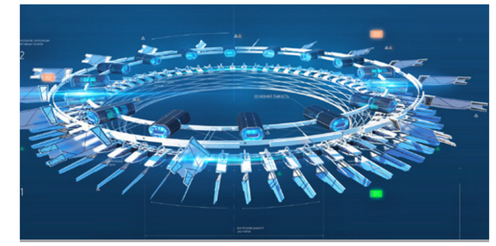


Image: (i14) Dubai 2050 intry by Iliya Klimov

Dubai 2050 is a levitating viewing platform designed by Russian futurist Iliya Klimov for Dubia 2050. The levitating viewing platform raises and lowers itself to allow access to the super-light structure. The design takes inspiration from several si fi space stations like the ring-shaped orbital station from 2001, A Space Odyssey.

Another architect named Georges Kachaamy has experimented in his free time for the last 20 years with super light structures and plans to present his designs at the next Dubai 2050 expo. His designs include several

Levitating Structure

Lira Luis, a California architect, spends her downtime experimenting with electromagnets in scale models. Designed as a potential solution to levitate houses above water in New Orleans, Louisiana, her experiments try to apply magnets to various structural connections on the model scale.

Interested in floating houses, Allen Pax patented a hover engine to temporarily float homes in seismically active areas. He used the machine on a skateboard to test the design, creating the world's first hoverboard. While only being able to hover over a copper track, the engine works and serves as an example of the current commercial viability of the technology.

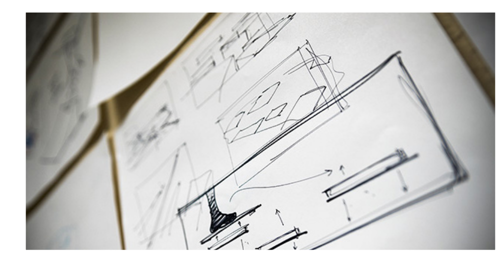


Image: (i15) Hendo Hoverboard Sketches

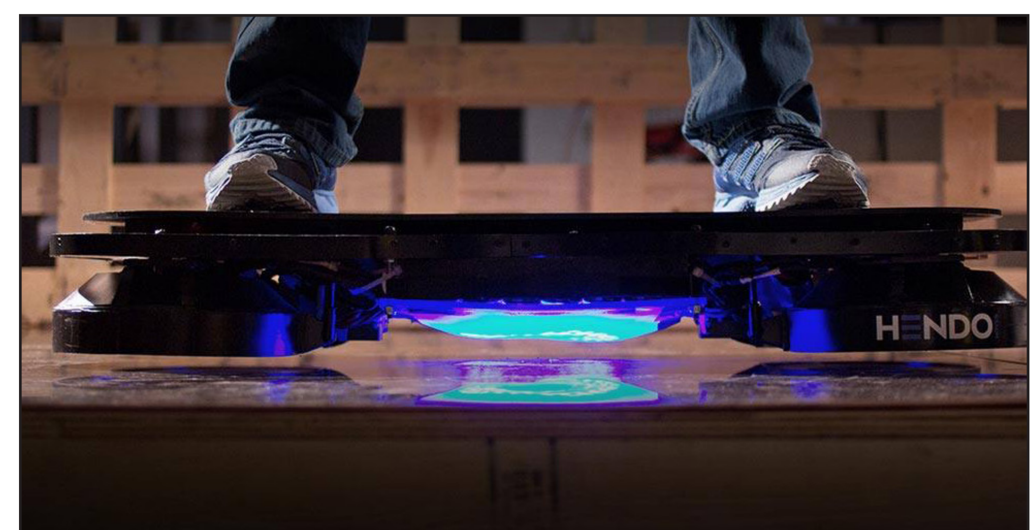


Image: (i16) Hendo Hoverboard

References: (i14) https://www.artstation.com/artwork/8NgPw (i15) http://hover.arxpax.com/newsroom/photo-gallery/ , (i16) https://hendohover.com/

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The Future and Architecture

Chapter: 4 The Future and Optimism

Why Optimistic

An optimistic look at the future of humanity and the planet is a progressive one and a view that focuses on not complaining about the state of things but dose something for the future. By thinking about the progression of technology in this way, we could perhaps find solutions to the here and know where not thorough possible before.

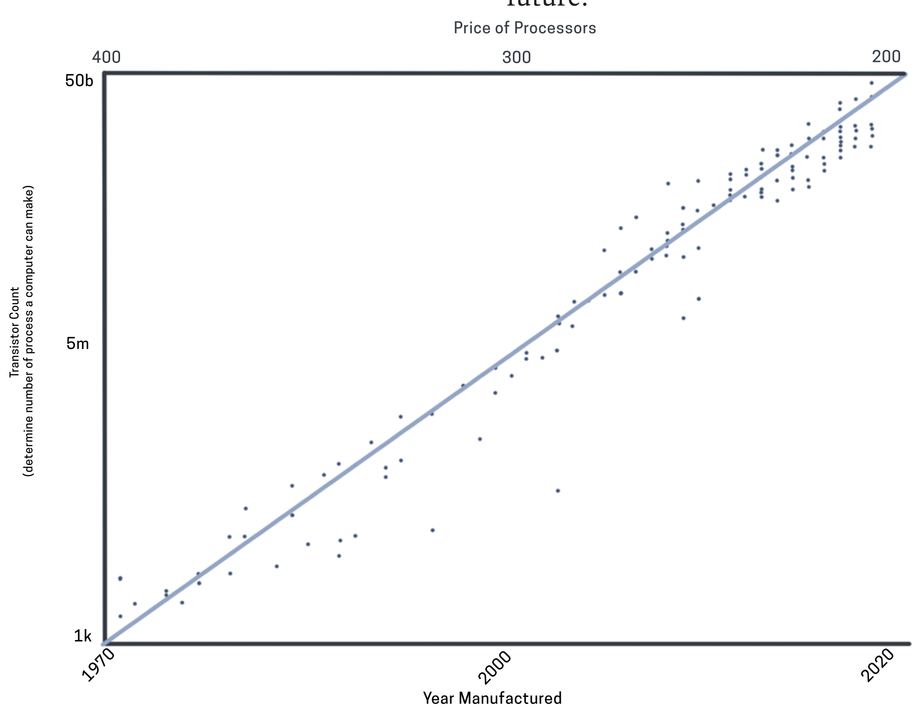
Technology's natural progression

As time goes on, technology trends to get smaller and more efficient, both in the operating and manufacturing scenes, Moore's Law is a great example of this; it states that the number of transistors in a computer doubles every year; this has held true since the 1970's when microchips were first introduced.

What the future could bring

Image: (i17) Illustration of an Orbital Ring

A combination of the scientific communities aspirations for space travel and recent material sciences research allows us to picture what kind of structures could be seen in the future. Using logic, known physics, statistics, material sciences, and precedence from the past, we can predict some very likely structures and technologies that we will use in the future.



Price and Complexity of Technology Over Time

References: (i17) http://www.bisbos.com/space_earthring.html

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The Future and Architecture

Chapter: 5 Future Crisis

A Multitude of Problems

The call for climate change action presents an impossible task to save the planet from ourselves; today, you'd be hard-pressed to find anyone who doesn't believe that the climate is changing. Throughout the history of the earth, the climate has had peaks and troughs of temperature change, some radical, some not. Still, this downward trend due to the advancements of human civilization has moved the average. Even before the Industrial Revolution, the release of CO2, methane, and other greenhouse gases has sparked a chain reaction of rising temperatures, melting sea ice, rising sea levels, and decreased salinity, which further changes the temperature and thusly currents cause violent weather phenomena. This, in part, is due to a dramatic population increase and, in this way, a massive demand for not only goods but shelter and services.

As temperatures rise, humanity faces a series of compounding problems as the ice caps melt, global sea levels rise, the oceans cool, changing weather patterns and creating more frequent violent weather phenomena. This issue stems from the 1000s of companies but the sear number of people and the modern way they live. This drive for better and more products and quality of living drives our modern economy. It is unavoidable to some extent, driving companies' competitiveness to search for ways to gain the edge by butting costs to provide even more goods to the ever-growing population. The growing population and the production of goods also compound with power production, construction, and transportation, contributing billions of tons of carbon to the atmosphere every year.

Image: (i18) New Orleans under water

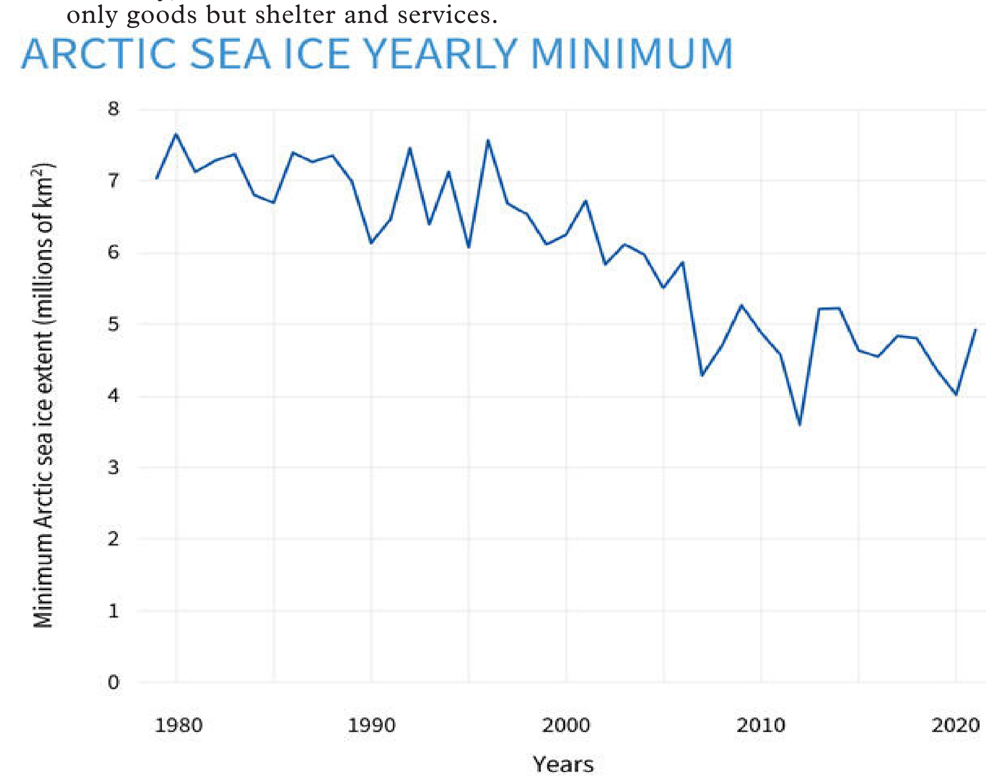

Figure: (f2) arctic Sea Ice melting over time

References: (f2) https://www.climate.gov/news-features/understanding-climate/climate-change-arctic-sea-ice-summer-minimum (i18) Downtown New Orleans flooded after Hurricane Katrina, 2005 iStock

Population Crisis

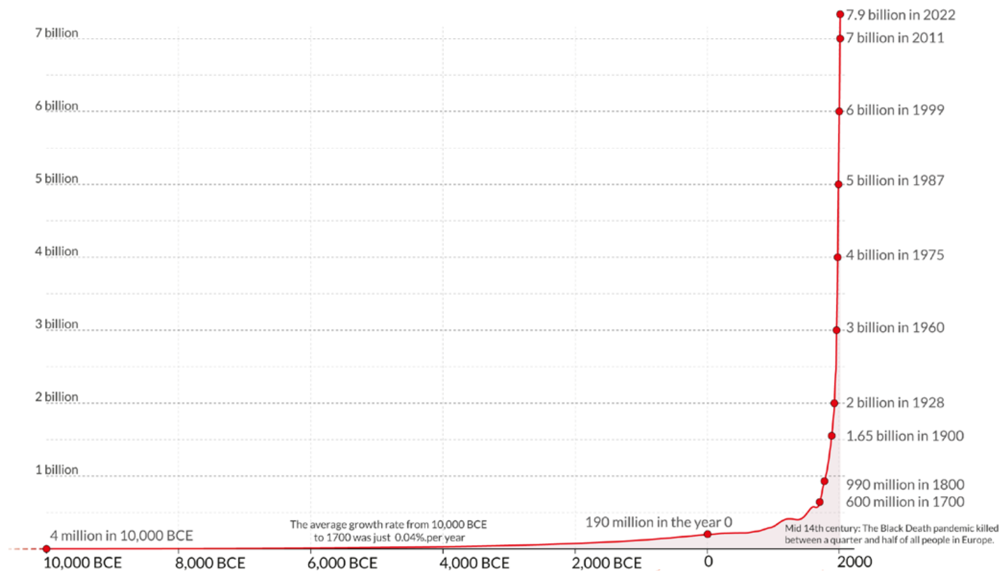

Figure: (f3) World Population in the last 12,000 years expected to reach 11 billion by 2100.

Figure *(f3)* shows the massive population growth, over 7.7 billion people, while some estimates show the graph leveling off in the next few decades. while ultimately anything can happen to populations in the future, such as pandemics and war, however currently, there is no significant sign of stopping the overall growth and according to Figure *(f3)* the population will continue to grow as long as a steady food supply exists to supplement it. In fact, over the next 100 years, some estimates put the world population at 2-3 billion more than the current 2020 numbers. With rising oceans and over half of the people living along near flood-prone coastal areas, billions of people will need new places to live, solutions to mass permanent flooding, and ways to save existing structures.

When considering this super-massive boom in earth's populations over the last few decades, it is apparent that a move towards a more ecologically friendly way of life is needed for humans and a denser one if we are to preserve nature.
Environment. As architects shift towards more and more green designs, they must realize the impact of so many people wanting to live in the countryside and the impracticality of that relating to the natural environment.

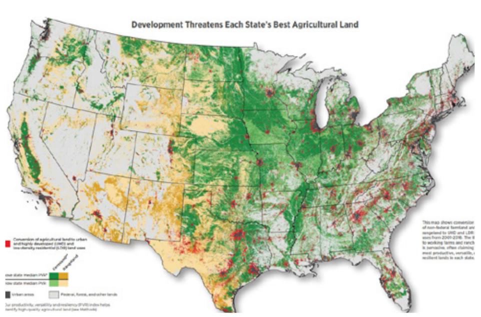

Figure: (f4) Shows the Urban Sprawl Boom of the 80s in red.

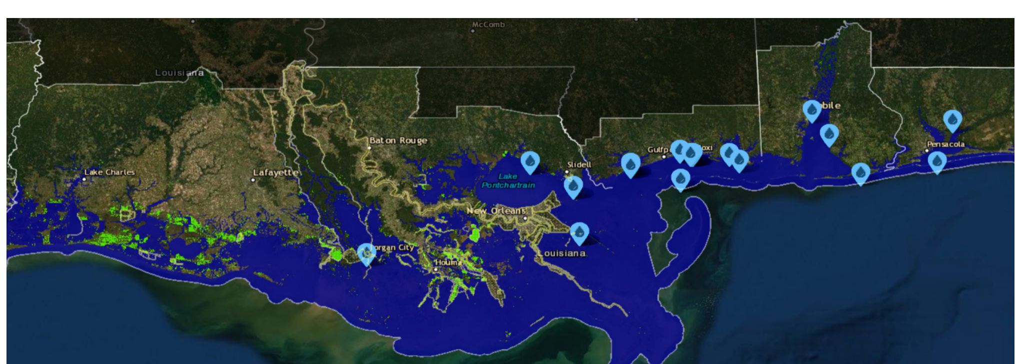

Figure: (f5) Shows the coastal flooding caused by Sea level in the current day

References: (f3) https://ourworldindata.org/world-population-growth, (f4) https://csp-fut.appspot.com/ , (f5) https://riskfinder.climatecentral.org/place/new-orleans.la.us?comparisonType=place&forecastType=NOAA2017_int_p50&level=6&unit=ft

The Power "Crisis"

With population comes power usage. The average 2020 US Citizen uses 10,909 kWh per year. Washers, Dryers, refrigerators, coffee makers, computers, cell phones, lights, microwaves, and TVs contribute to each person's carbon footprint. This number doesn't even take into account workplaces, the average office building's power consumption. Combined with the upcoming electric car these facts put the civilized world at risk of unreliable power.

The massive amounts of coal, natural gas, and the petrol used to power and heat our homes are lower; it is clear we still have many years to eliminate reliance on them, and we can eliminate dependence on them.

Solar panels efficiency has reason greatly over the last few years and is only going to get better.

Nuclear fusion power has seen great leaps and bounds as well, with increased security measures as well as Proper nuclear waste disposal methods are finally being implemented. With different kinds of fuel and reactor types being used, the future of atomic power is bright.

Fusion, a hotly debated power source, has been seemingly always 30 years away from being fully developed. However, in the south of France, a massive collaboration of over 35 different countries over the past 40 years has been slowly coordinating research and development on a gigantic fusion reactor. A project in France will provide over 100 times the power output of a standard nuclear reactor. This coalition is also only one of many groups working on different fusion designs.

These solutions will solve the power crisis in the coming decades and provide clean energy for all on a massive scale, potentially even creating a surplus of power, making humanity into a post power scarcity society.

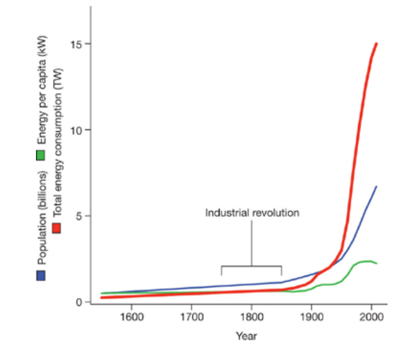

Figure: (f6) Population and energy consumption

Credit fo PictureOptat. IgentiaBessusque

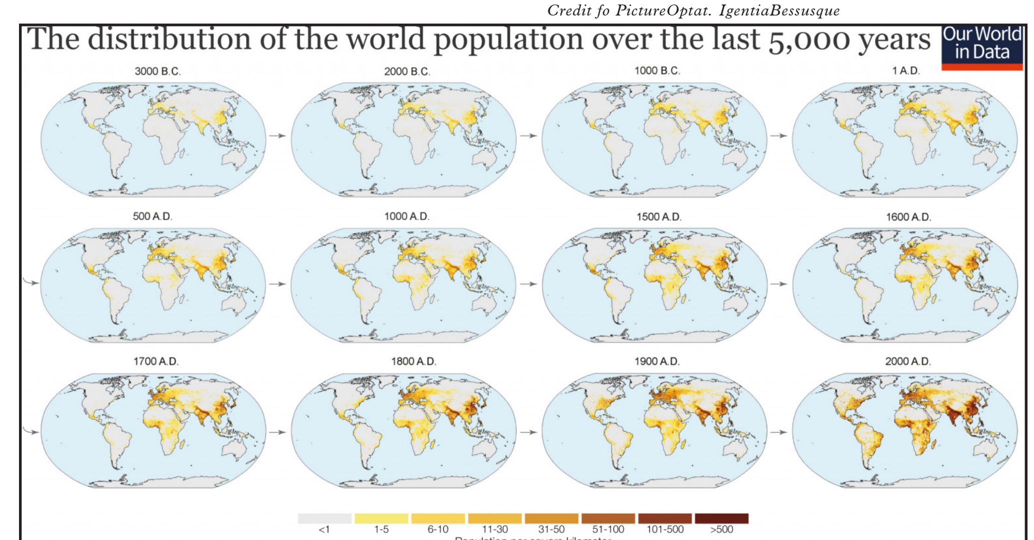

Figure: (f7) Distribution of world population over 5000 years

References: (f6) https://kennorphan.com/2015/07/15/our-common-humanity/ , (f7) https://ourworldindata.org/world-population-growth

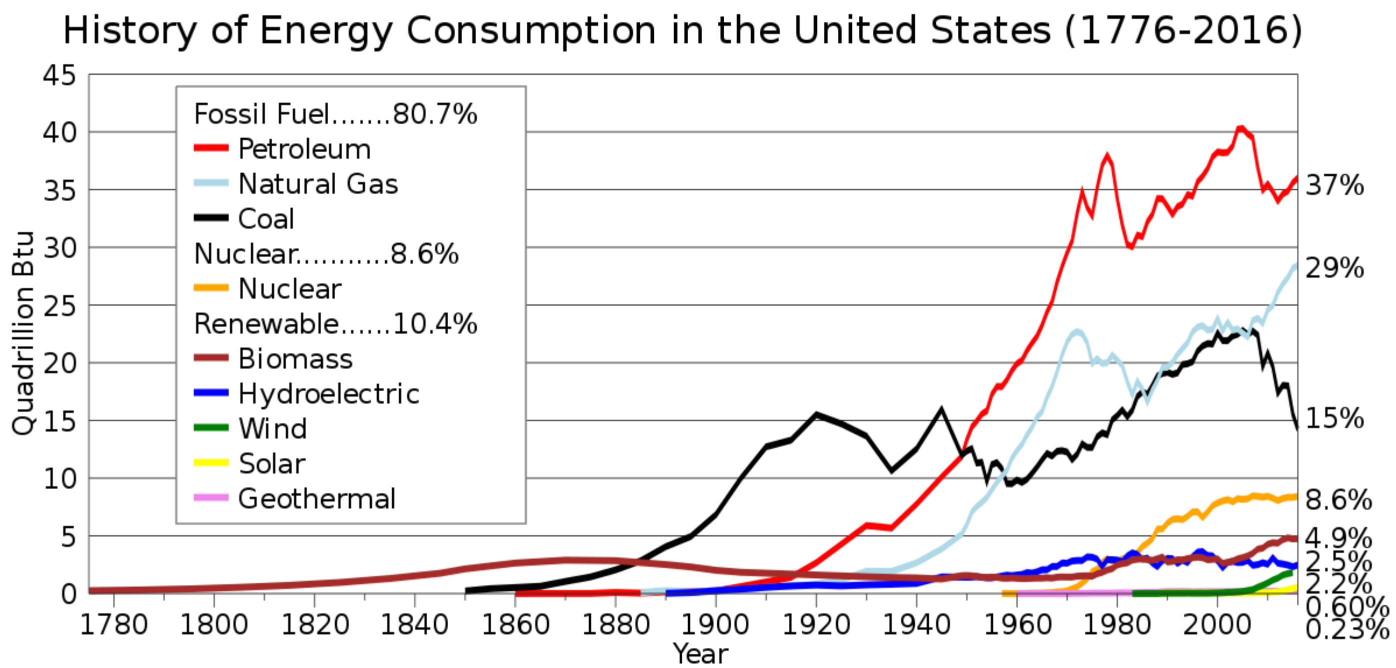

Figure: (f8) Graph comparing different energy generation usages over the last few decades.

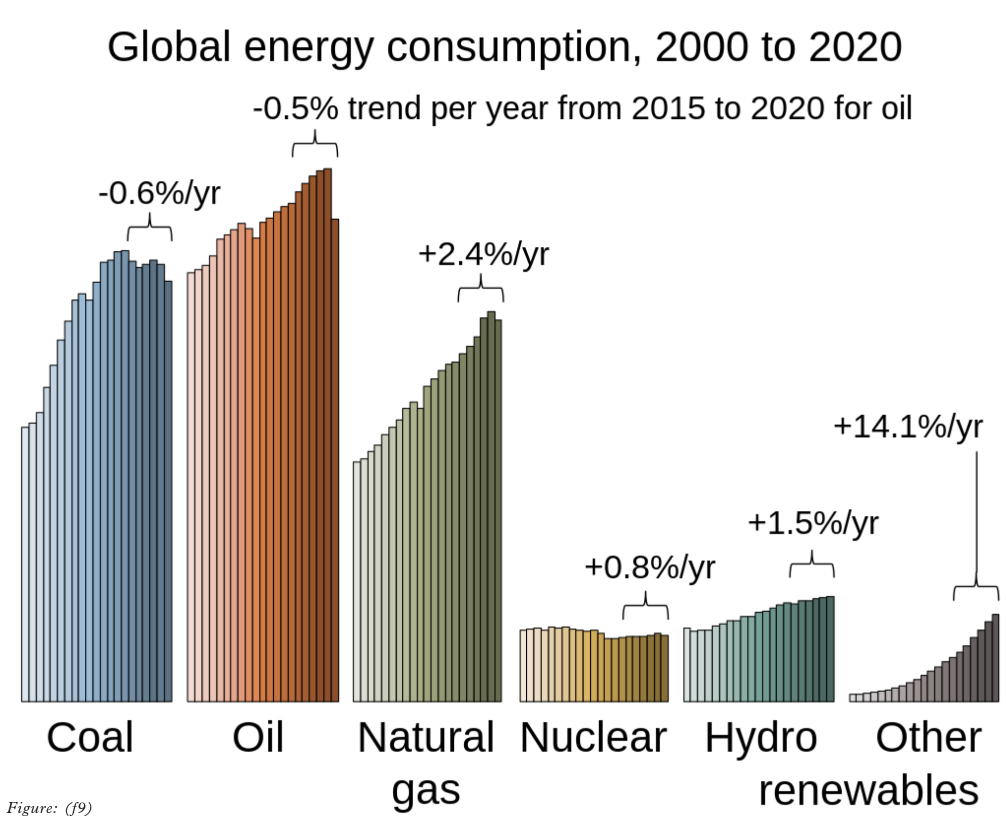

Figure: (f9)

References: (f8) Wikimedia Commons , (f9) https://robbieandrew.github.io/GCB2021/

I

The Future and Architecture

Chapter: 6 Looking at the Past

Introduction to the Past

This next chapter will look at three civilizations dealing with three icon materials and structural systems that they used. For simplicity, we will break up structural typology for each era into three main categories; Span, Volume, and Hight. These are good measurements of what humanity commonly tries to overcome. Span is always important in each civilization, primarily used to bridge what is needed to move people and goods from one location to another. Volume or uninterpreted interior volume is another helpful measurement in history. We will look at multiple examples of fitting large amounts of people or goods into a space for a specific reason. Hight our last category is trickery being used for several reasons throughout history, from getting vast amounts of people into a small footprint to pure vanity. The following chapter will start with the Ancient Roman Empire and how they used concrete and arches in their architecture. Then we will discuss the industrial revolution of the 1800s and the use of wrought iron and truss and column systems. Then to the Modern Era to the present, where Steel and concrete make up the majority of structures.

The Three Foci

Three categories have been carefully selected to represent the human endeavor to push architectural and structural ingenuity. Spanning will focus on the uninterrupted middle span of bridges. The volume will focus on the uninterrupted or seemingly uninterrupted fully enclosed spaces; as for Height, it's pretty self-explanatory.

Spanning

Built for not only economic reasons but also for strategic military purposes, bridges have helped humanity connect over separators. Even bridges that start for the military can turn economic like Trajan's Bridge, or economically and socially like those in cities throughout the ages. Focusing on the key civilizations mentioned before, bridges using technology new to their respective civilization are usually the first to be built. It is because it is more socially or economically acceptable if the bridge fails; the fact is that bridges are generally the first.

Volume

Many architects have wanted to create large and larger interior spaces from the dawn of civilization, whether it attempts to awe and project power, like the Persians and their Hundred Columned Hall, or provide distractions for the masses, like the Romans and their arenas.

Height

Height can do many things from creating landmarks to creating an efficient and condensed living space for people to live and work, or even as a vanity project to promote and showcase the power of government or corporation, height is imperative for humanity moving forward if the earth becomes more and more populated.

Image: (i19) Lighthouse of Alexandria

References: (i19) DEA Picture Gallery / Getty Images

Image: (i20) Bridge of

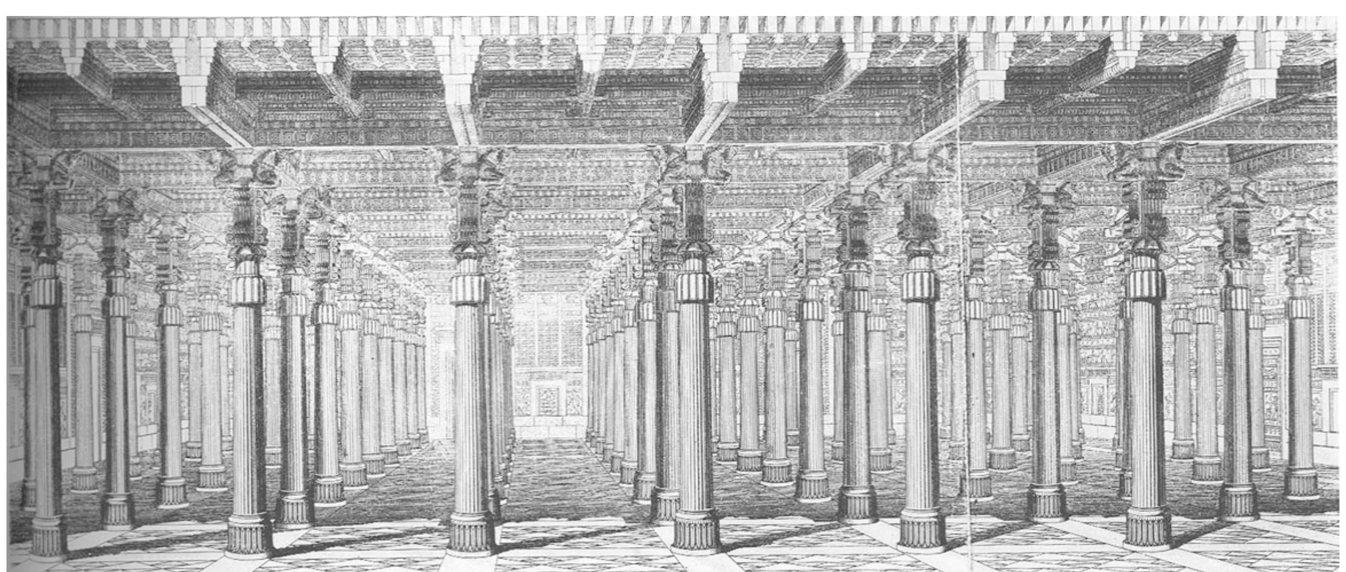

Image: (i21) Persian Hall of a hundred Columns

References: (i20) E. Duperrex in 1907 https://worddisk.com/wiki/File:Trajan%27s_Bridge_Across_the_Danube,_Modern_Reconstruction.jpg/ , (i21) sketch from 1870 / Hundert-Säulen-Halle

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The Future and Architecture

Chapter: 7 Evolution of the Span

Spanning

Spans have been an integral part of civilization since the dawn of humanity. The crossing of rivers and gorges and even over other structures is an essential part of not only trade but projecting military might.

Aqueducts

Bridges were not just for people, but the Romans were the first to use them to move massive amounts of water from higher elevations to lower ones. Bridging over valleys and digging through mountains to keep an exact gradient, the aqueducts of the Roman era used arches and concrete as a go-to means of support.

The First Arches

The first arches didn't appear in ancient roman but rather in ancient Mycenaean Greece, and the first known example is the Arkadiko Bridge, built of massive cyclopean stones. Arches appear again in many forms as bridges, entrances to structures, and city gates. Like arches, the Romans also didn't invent concrete. Nabataea traders were the first known uses of concrete, using the substance to make floors for their houses. While the ancient Romans didn't invent either of these, they did undoubtedly perfect them.

The First Roman Bridges

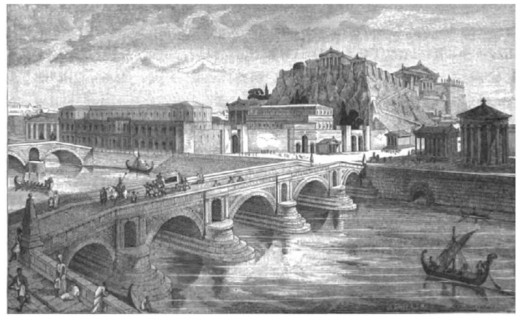
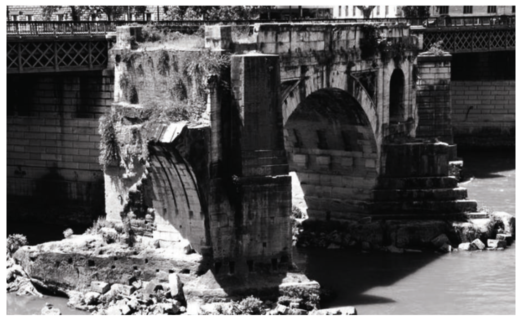
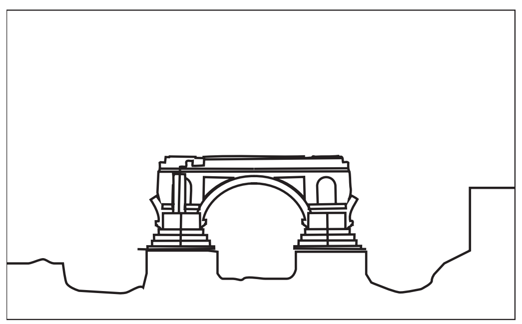
The Pons Aemilus was one of the first bridges in Rome, built several times starting as early as 142 BC to cross the Tiber. Today, the bridge itself can be seen as a ruin next to a new bridge.

Late Roman Bridges

As the Roman period stretched on through the centuries, concrete arches of the bridges and aqueducts became more and more impressive, becoming bigger and bigger.

Image: (i22) Oldest arch bridge in the known world

References: (i22) Wikimedia Common

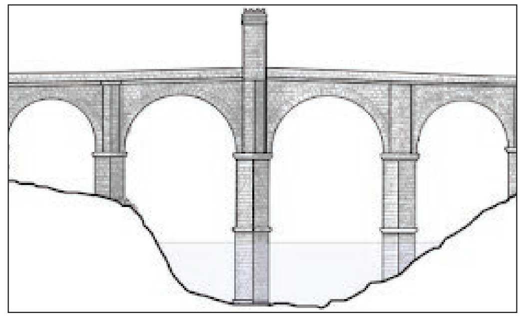




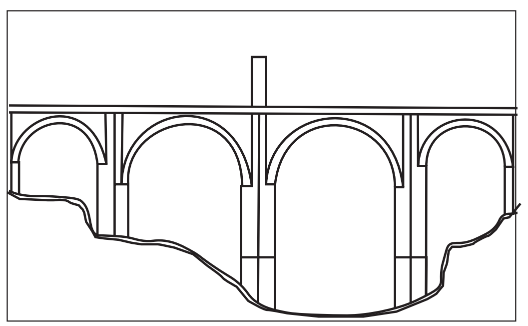
PONS AEMILIUS

LOCATION / DATE
Rome, 142 BC

ARCHITECT
Marcus Nobilior
Scipio Aemilianus

INNOVATION / DETAILS
Oldest stone bridge in Rome
Span ~ 30'



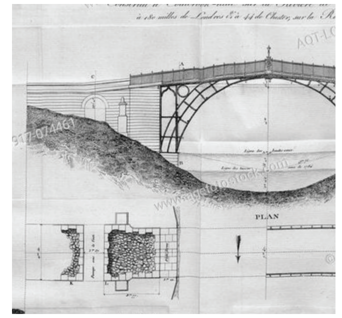


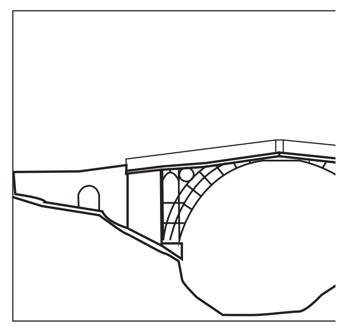
ALCÁNTARA BRIDGE

LOCATION / DATE
Spain 106 AD

ARCHITECT
Caius Julius Lacer

INNOVATION / DETAILS
Longest spans at the time.
Span 94'



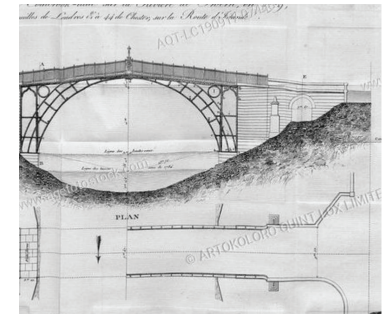


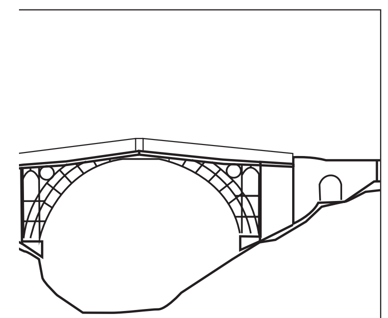
THE IRON BRIDGE

LOCATION / DATE
Ironbridge, UK 1781

ARCHITECT
Thomas Pritchard
John Wilkinson

INNOVATION / DETAILS
First structure to be
cast iron. Span 100



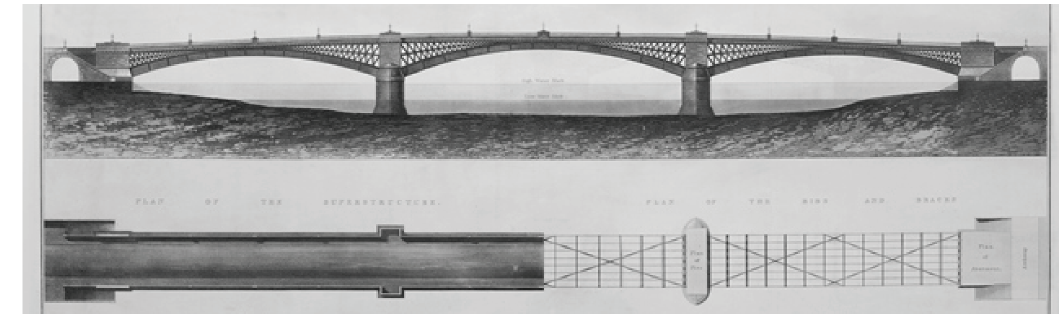


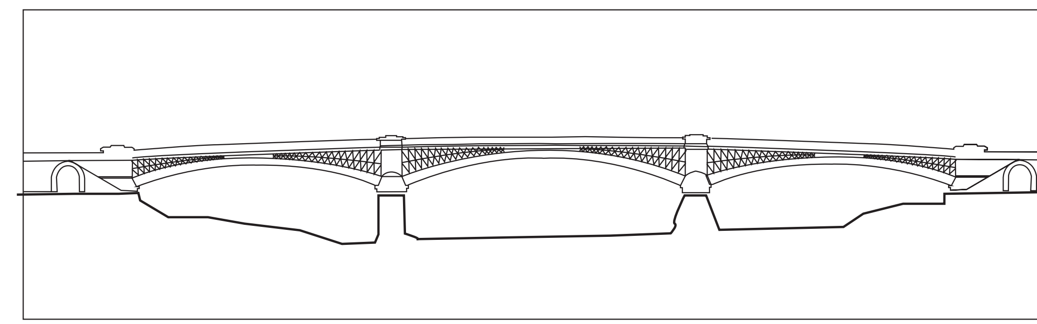
BRIDGE

DATE
e, UK 1781 AD

ɔritchard
ʞinson

ɴ / DETAILS
ıcture to be made of
. Span 100'





SOUTHWARK BRIDGE

LOCATION / DATE
London, UK 1819 AD

ARCHITECT
John Rennie

INNOVATION / DETAILS
The longest cast iron span
ever. Span 240'

Spanning Distances

Industrial Revolution

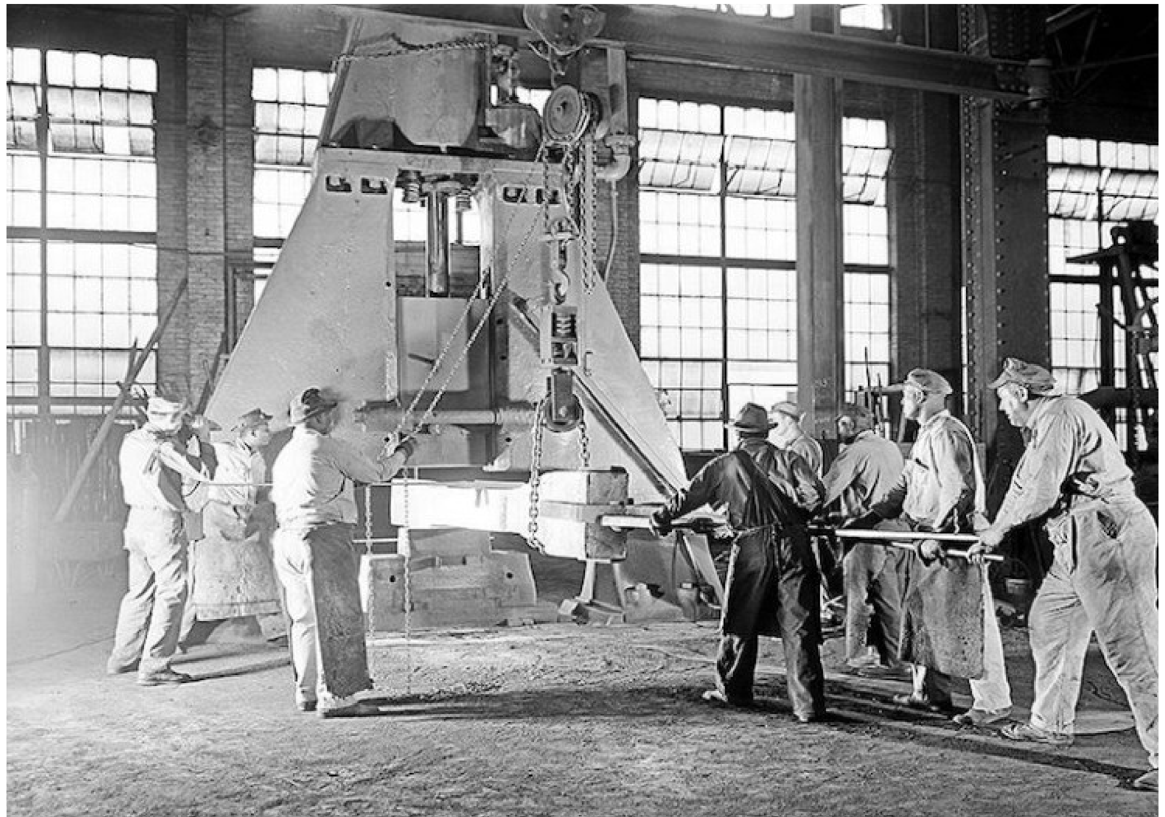


Image: (i23) Iron being worked on a massive Steam Hammer

Iron in vast quantities and new working methods in the early 1800s made the industrial revolution possible. Before, iron in architecture was used sparsely and primarily for bracing stone structures due to its expensive rarity and production cost. Cast iron changed all that.

The First All Iron Bridge

Iron Bridge which spans Iron Gorge in the north of England, named for, of course, the vast amounts of the iron mined there, was the first structure ever to be built using cast iron.

Late Industrial revolution Spans

As the industrial revolution stretched onward, iron was used in increasing quantities in bridges and industrial applications.

As architects began to use iron in architectural applications during the latter half of the 18th century, some architects were higher to design them, when previously bridges were almost entirely done by engineers.

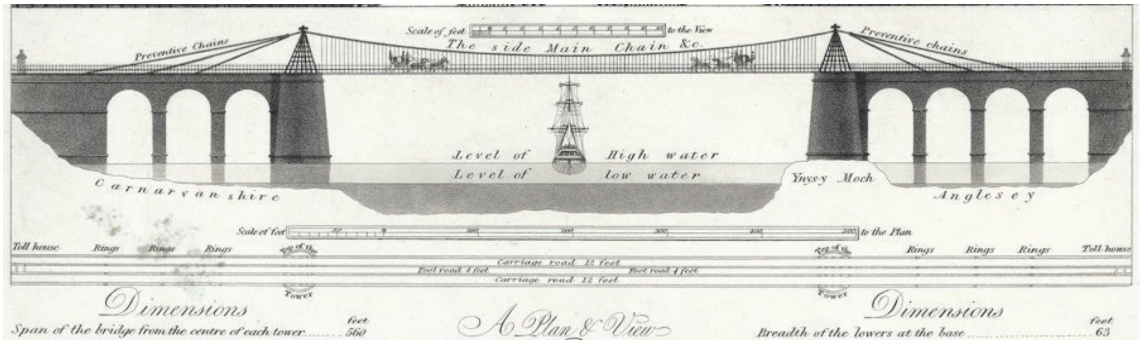
References: (i23) SMU Central University Libraries/Flickr

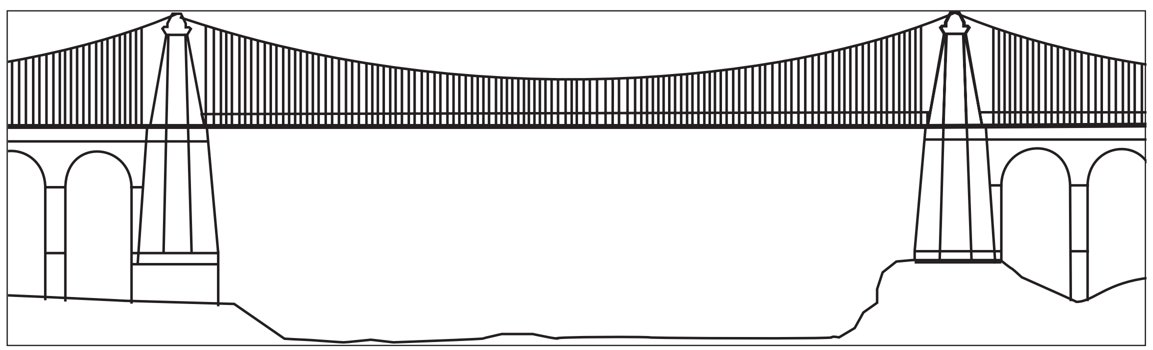
The Modern Era Spans

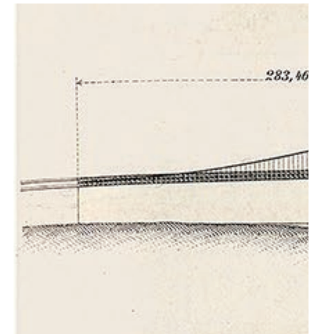
During the late 1800s, as technology started, its ever-increasing upwards trend continues to this day, and new methods of steel production came to light. Suspension bridges appeared, and other tension-based bridge types as specialization took hold of the modern world.

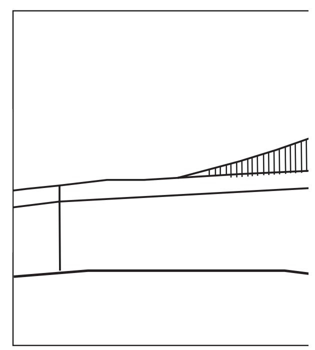
Image: (i24) The Mackinac Bridge above the Straits of Mackinac 1957

References: (i24) File photo/Detroit Free Press









MENAI BRIDGE

LOCATION / DATE
Wales, UK 1826 AD

ARCHITECT
James Buchanan Eads

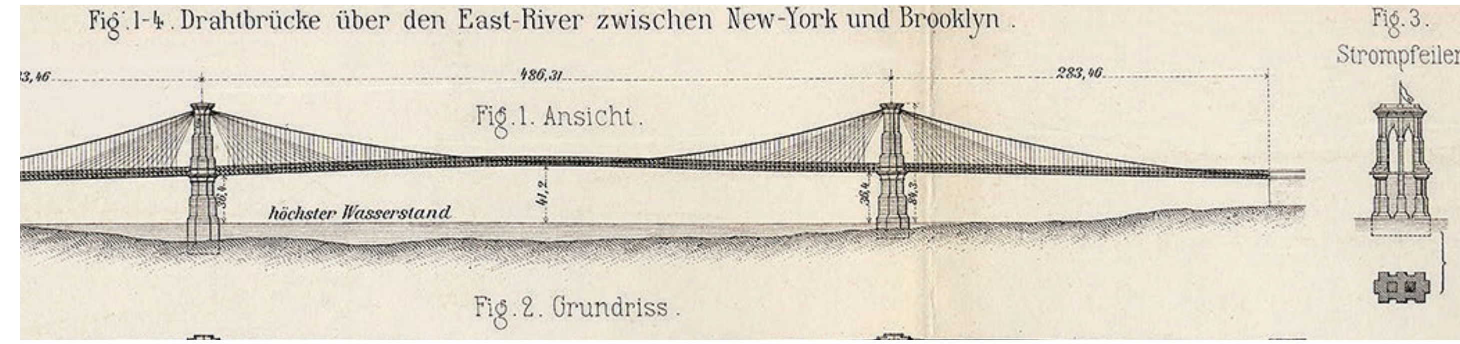
INNOVATION / DETAILS
The First Suspension bridge. Used Iron Chains insted of the cables of todays bridges. Span 577'

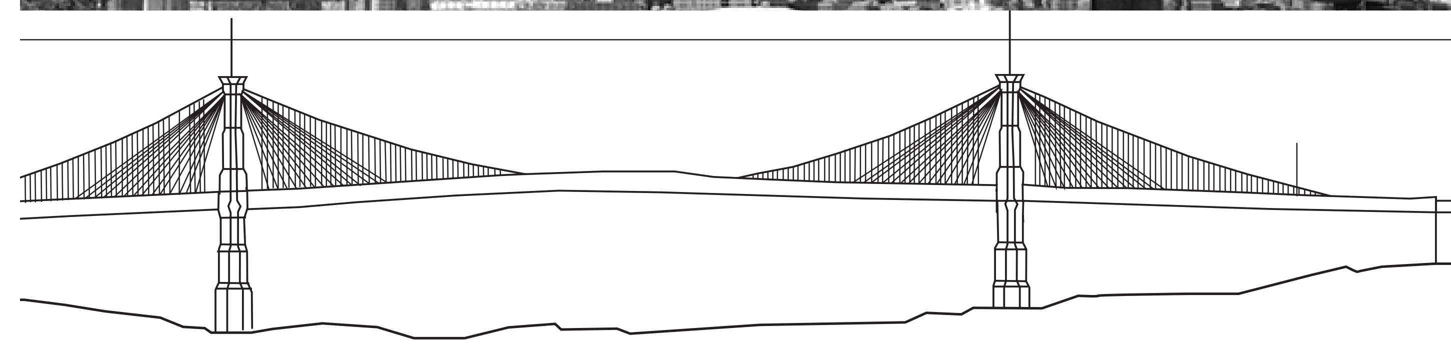
BROOKLYN BRIDG

LOCATION / DATE
New York 1883

ARCHITECT
John Roebling

INNOVATION / DETAIL
The first stee
bridges in the w
longest in the
years. Span 1,59





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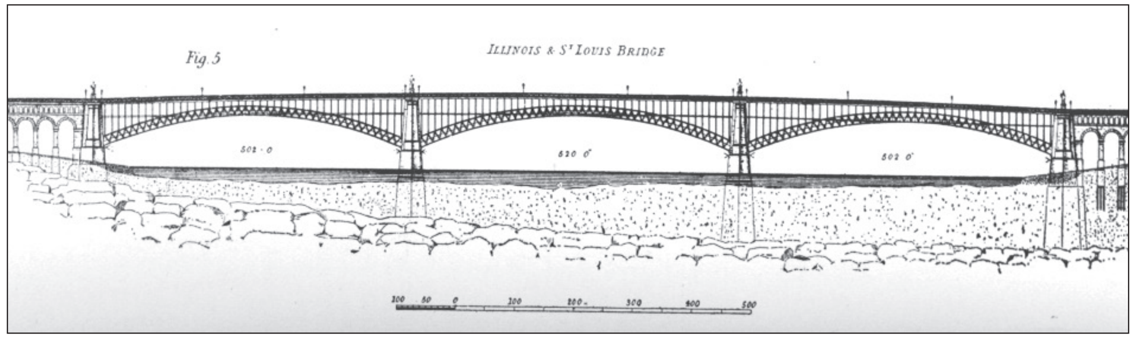
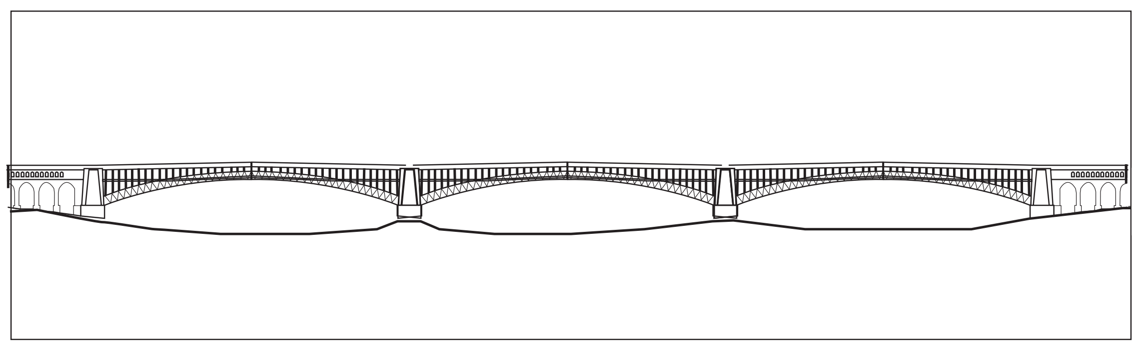
595'



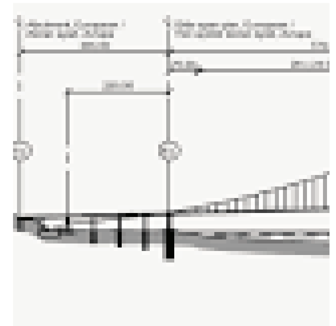


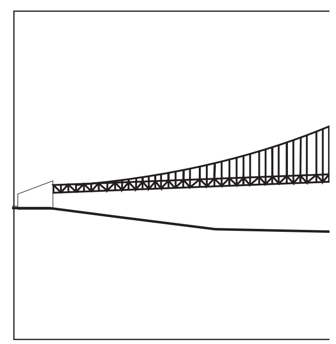
EADS BRIDGE

LOCATION / DATE
St. Louis, Missouri 1874

ARCHITECT
James Buchanan Eads

INNOVATION / DETAILS
One of the first bridges in the world to use steel as a major structural element and signified the switch from Iron. Span 520’



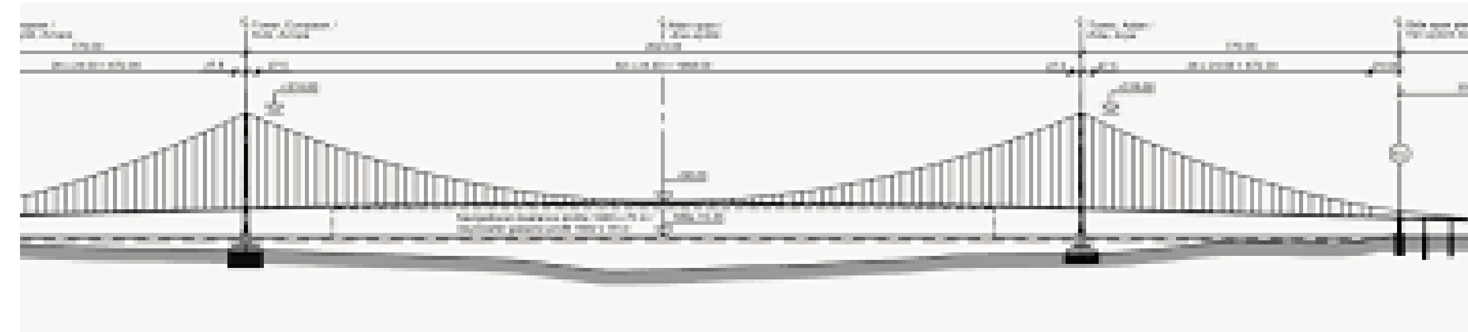


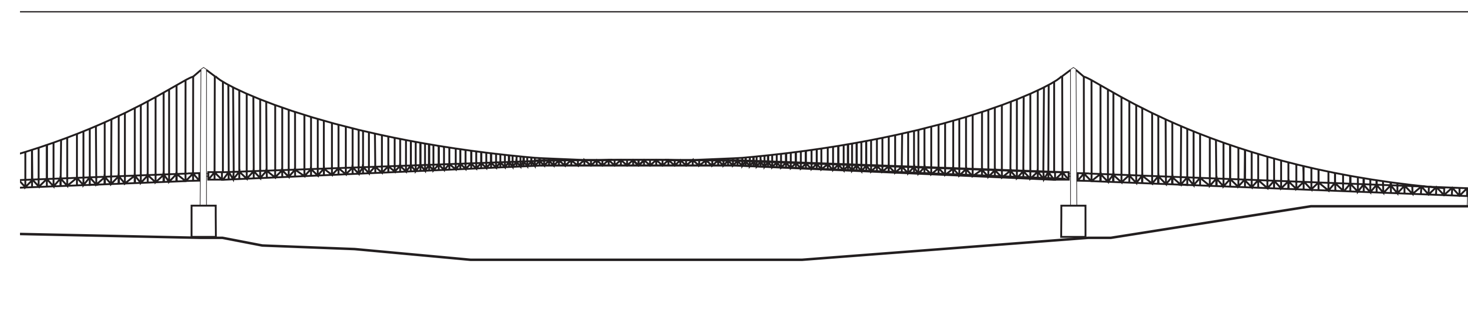
AKASHI KAIKYO BRI

LOCATION / DATE
Akashi, Japan 19

ARCHITECT
Satoshi Kashima

INNOVATION / DETAILS
The Longest Su
the world. Span 6,





) BRIDGE

1998 AD

ma

AILS
Suspension in
n 6,532’

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The Future and Architecture

Chapter: 8 Evolution of the Volume

The evolution of volume throughout human civilization is apparent through archeology. Throughout time every civilization has sought to create grandiose spaces, from memorializing the dead to commemorating the god and kings.

Image: (i25) Ancient Assyrians cobbled domes

Volume of Rome

Rome's usage of the arch and thusly the dome significantly contributed to their mastery of interiors. The visions of Romes architects so greatly influenced the world today that it is quite frankly impossible to imagine a world without their influence. To talk of how Romans created volume, a look at the Pre-Roman civilizations is necessary; in the last chapter, we touched on the borrowing of the arch and concrete necessary. Before we begin here, we will touch on how volume was perceived before Rome and the early iterations of the dome.

Image: (i26) Temple at Karnak at 1700 BC

Early Volume

23,000 BC is the date for the 1st ever domed structure, made of mammoth tusks; the primitive hut was found in Ukraine. Many early designs used this style of hut to live in. In the middle east, around 6,800 BC, the ancient Assyrians used mud brick grain silos that used a cobbling technical. Egypt also used this cobbling technical for domes in the mastaba tombs of the Old Kingdom. In Mycenae, Greece, the Treasury of Atreus is one such example of an exquisite cobbled dome tomb still standing today. Domes, however, were not the only way space was handled; large Columned halls of stone were a favorite of both Egypt, Persia, and Greece, each handling layout, purpose, and application differently.

Image: (i28) Baths of Diocletian in Rome 306AD

Late Volume

Even as the Roman era started to decline, massive structures were created, such as baths, amphitheaters, and various palaces. When the empire split, the even western roman empire started making many immense structures, including baths and palaces, and when Christianity became the state religion, Churches.

Both early and late roman architectural designs involving volumes focus on making one of two types of structures. The first of which is Structures under a public works category which can be separated into three subcategories focused on distracting the public through various means, entertainments like the Colosseum, structures focused on public health like the great baths of Diocletian or various cisterns, and structures with religious of governmental purposes such as temples and basilicas. The second type of structure consists of various private palaces and villas.

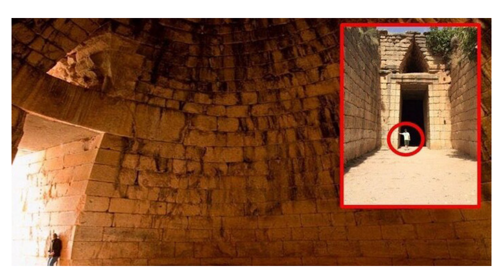


Image: (i27) Treasury of Atreus

References: (i25) Drawing of an Assyrian bas-relief from Nimrud. , (i26) https://discoveringegypt.com/rebuilding-ancient-egyptian-temples-in-3d/ , (i27) Screenshot from thumbnail of Mystery History video Youtube , (i28) E. Paulin (1890)

The first BIG Spaces

After the collapse of Rome, the medieval era in Europe saw a massive decline in structure capability. While Gothic architecture saw some significant leaps in the understanding of arches and tested the limits of stonework, the renaissance saw the erection of great domes in papal states. It wouldn't be until the industrial revolution and the mass production of prefabricated iron components that even larger spaces could be created.

The Worlds fairs

As the university from the late renaissance era spread and more scholarly schools set the stage for the spread of knowledge to the common folk instead of just the elite, various inventions accelerated further the progress of humankind. The printing press allowed for the general consumption of knowledge in native languages as to the aristocratic touge that was Latin. Various naval technologies allowed ships to sail longer distances quicker, connecting more and more people and thus ideas.

This growth happened in the major cities of the times, creating a mix of cultures and ideas throughout them; this internationalism convalesced in the form of worlds fairs. At the World's Fair, a host country would invite diplomats and civilians to come to their country and show off any inventions and technology that that country had created. The host country providing a venue for this to happen would petition architects in their country to build said venues to impress. These structures in and of themselves would be a showcase of the technology of the era.

Volume in the late 1800s

The crystal palace was the first fundamental massive structure to kick off the trend of the super volumes of spaces that all other fairs would seek to copy. While not creating a large unsupported interior, the interior was seemingly infinite as it cleverly used thin iron and plate glass for bathing the entire interior in natural light, the first building of its kind to do so. Later, the Polish and the French and others would do similar methods to create the Rotunda and Galerie des machines, respectively.

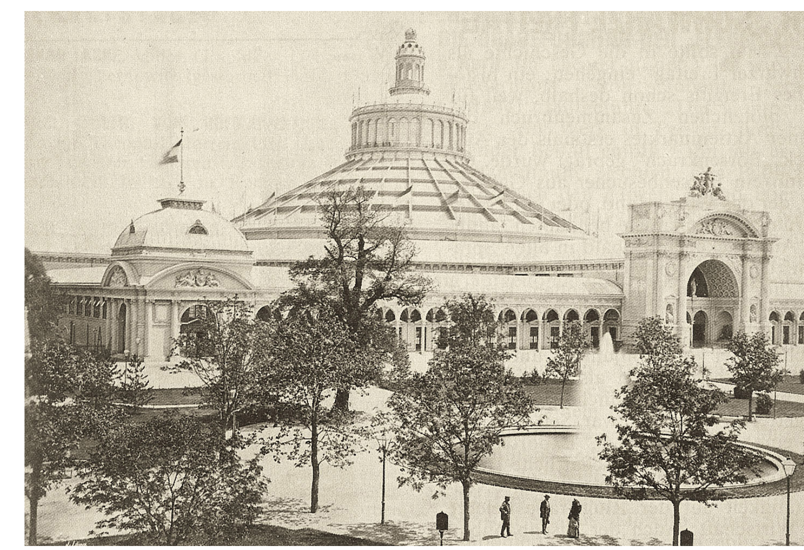
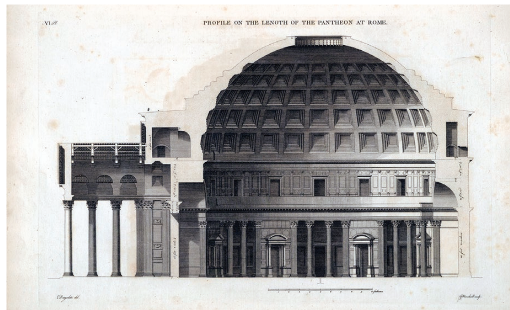
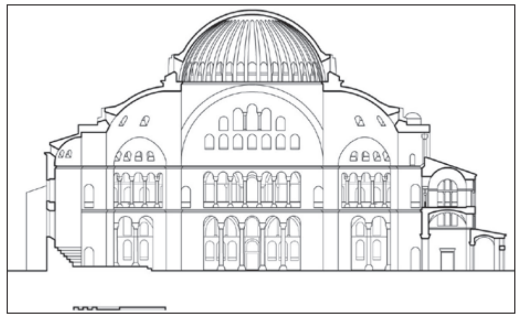
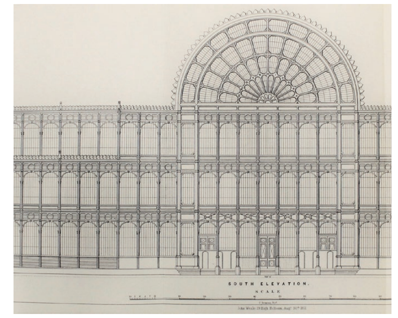
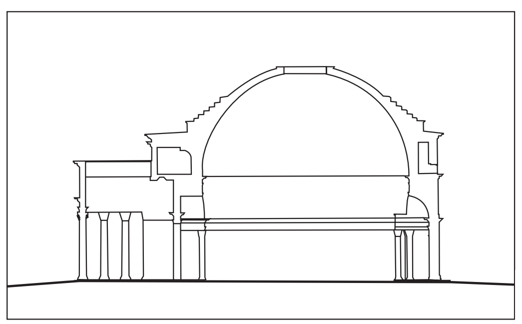
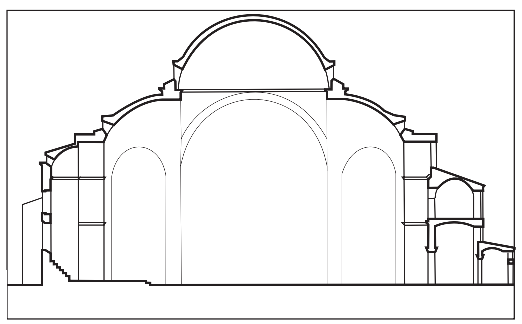
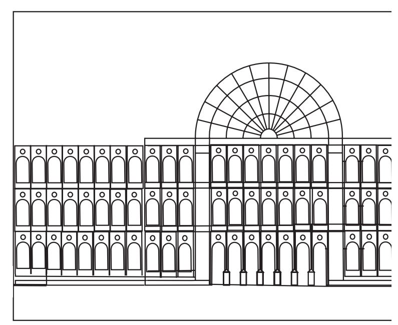


Image: (i29) Rotunde 1873 Vienna World's Fair

References: (i29) Stadtchronik Wien, Verlag Christian Brandstätter, page 316



PANTHEON

LOCATION / DATE
Rome 125 AD

ARCHITECT
Marcus Agrippa

INNOVATION / DETAILS
The largest dome in the world for 1300 years. The largest unsupported dome. Volume ~ 1.6 Million ft³

HAGIA SOPHIA

LOCATION / DATE
Constantinople 537 AD

ARCHITECT
Anthemius Isidore

INNOVATION / DETAILS
The largest cathedral for 1,000 years. First use of Pendentives for domes. Volume 150' ~ 1.7 Million ft³

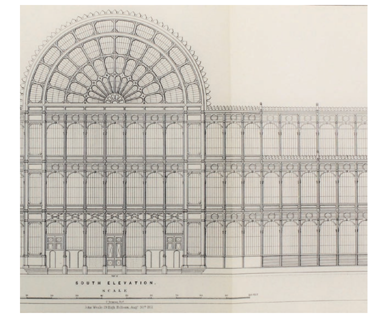
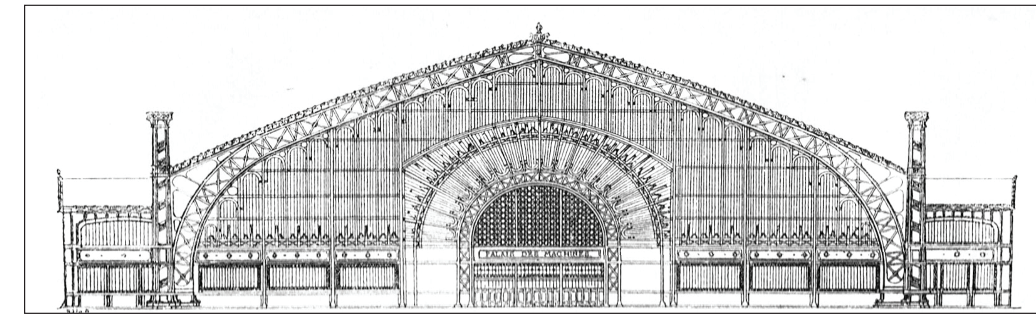
CRYSTAL PALACE

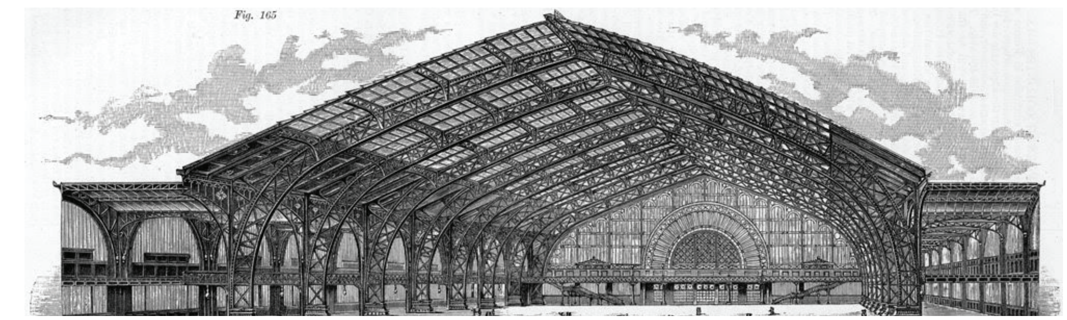
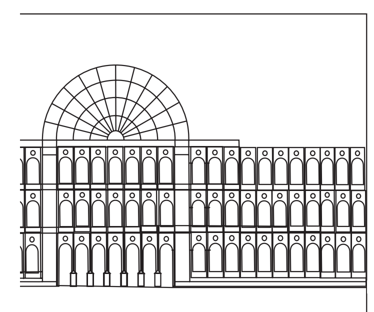
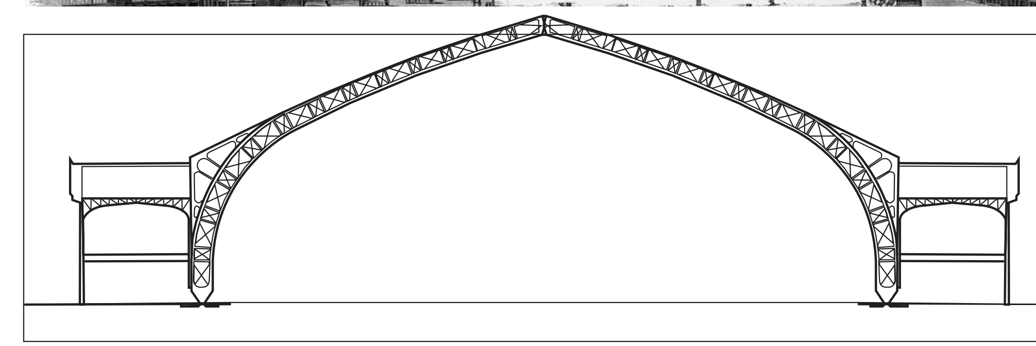
LOCATION / DATE
London 1851 AD

ARCHITECT
Joseph Paxton

INNOVATION / DETAILS
First use of prefabricat components. First use sheet glass. Volume ~ Million ft³

Interior Volume

ALACE

DATE
351 AD

axton

/ DETAILS
of prefabricated nts. First use of ss. Volume ~ 10.7

GALERIE DES MACHINES

LOCATION / DATE
Paris 1889 AD

ARCHITECT
Ferdinand Dutert

INNOVATION / DETAILS
The largest vaulted building in the world at the time. Inspired by the Crystal Palace. Volume ~ 43.5 Million ft³

Volume in the Modern Era

Steel, Concrete, and new ways of using them in structural design have led to some of the biggest interiors that mankind has ever conceived.

The Industrial revolutions shift into the modern era was far more immediate than previous technological shifts throughout history. Trying to create Better Iron lead to the creation of better steel. This, followed by the rediscovery of concrete and the dissolution of the ruling elite in Europe, led to the creation of many new styles in architecture. As the industry made materials less expensive, prefabricated components became more common, shifting architecture away from its ornate past.

Some created spaces that felt large using thin structural elements; others used steel-reinforced concrete with various structural technicals to make large spans inside structures possible. For the first time, structural engineers became necessary to work alongside architects to create the spaces they envisioned.

Some like Nervi created concrete structures that used various coffered grid-like vaulting to create vast open spaces. Buckminster Fuller used glass and steel to make the grid-like spherical designs that supported themselves.

Massive steel truss structures of various shapes would be purpose-built to precisely calculated loads generated on computers to create modern stadium interiors.

Conclusion on Volume

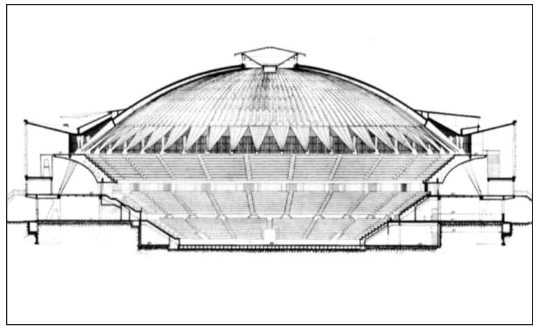
Overall, volume throughout the ages is usually the last constructed of the tree focus. As volume conclusively focuses on the entertainment and thusly distraction of the masses, it is treated more carefully than the other focuses. An example of this would be a bridge using concrete and steel would be built before a skyscraper, which would be built before a stadium because the bridge serves both economic and military functions, the skyscraper serves an economic function, and the stadium serves a less important function of pleasing the people, which while is important for the long term health of a nation, it isn't as important as establishing the economic well being and defense of itself and its people.

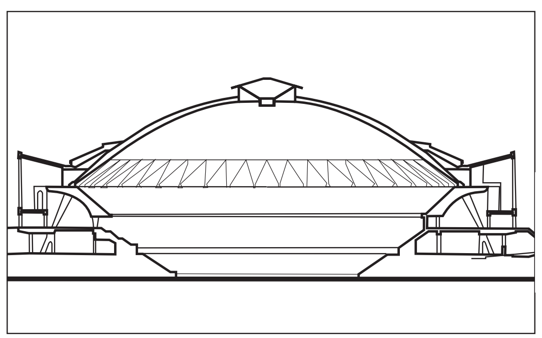
References: (a)

Image: (i30) The Packard Plant1954

Image: (i31) Inside the Packard Plant

References: (i30) John Lloyd , (i31) The National Automotive History Collection & Dr. Gary Gagliardi



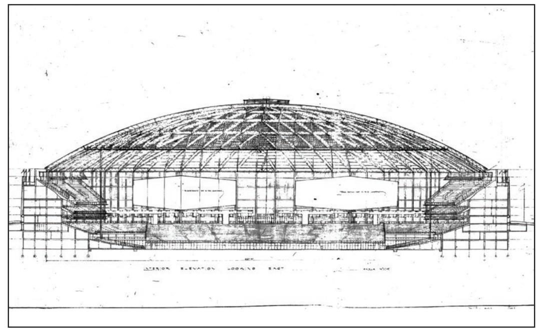


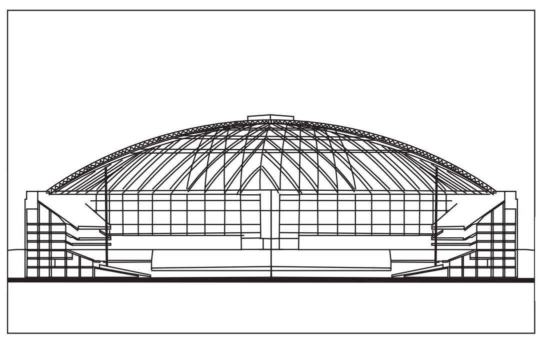
PALAZZETTO DELLO SPORT

LOCATION / DATE
Rome 1957 AD

ARCHITECT
Annibale Vitellozzi
Pier Luigi Nervi

INNOVATION / DETAILS
1620 individually prefabricated concrete sections built in only 40 days.
Volume ~ 27.28 Million ft³



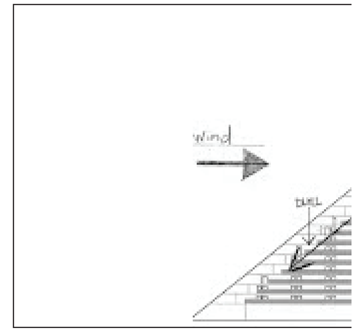
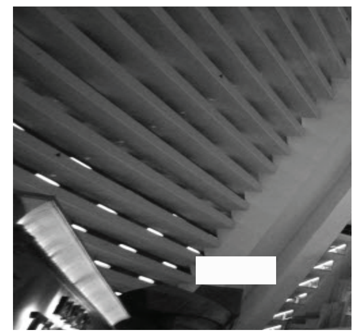
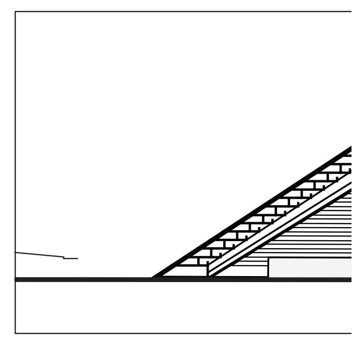


ASTRODOME

LOCATION / DATE
Houston, Texas 1965 AD

ARCHITECT
Morris Architects

INNOVATION / DETAILS
The first multi purposed domed stadium and the first stadium to use artificial turf.
Volume ~ 51.5 Million ft³

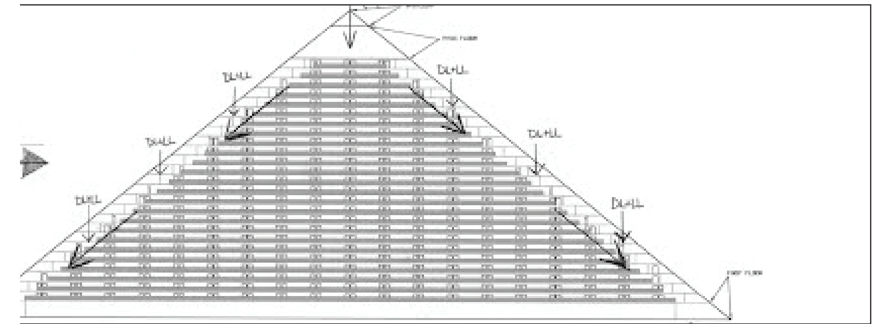




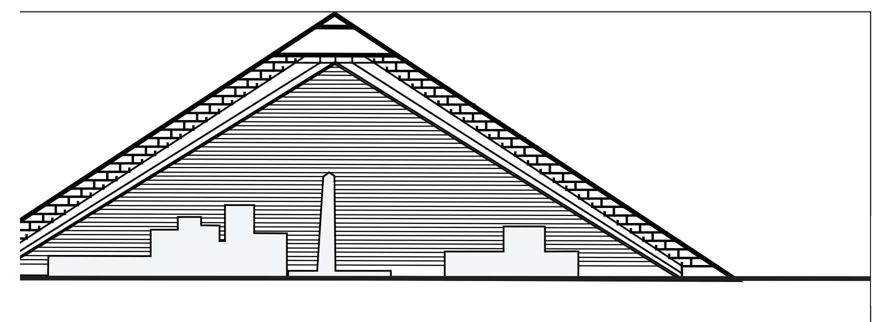
LUXOR HOTEL

LOCATION / DATE
Las Vegas, USA 19

ARCHITECT
Veldon Simpson

INNOVATION / DETAILS
At the time the larg
atrium and the 4th l
pyramid in the worlc
29 Million ft³





SA 1993 AD

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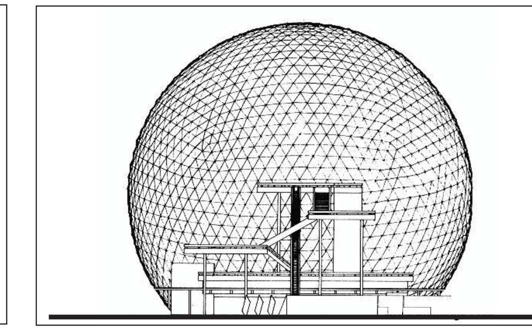
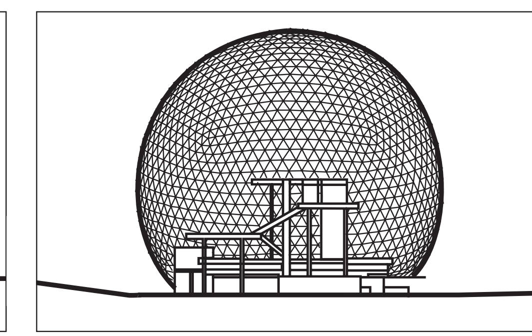


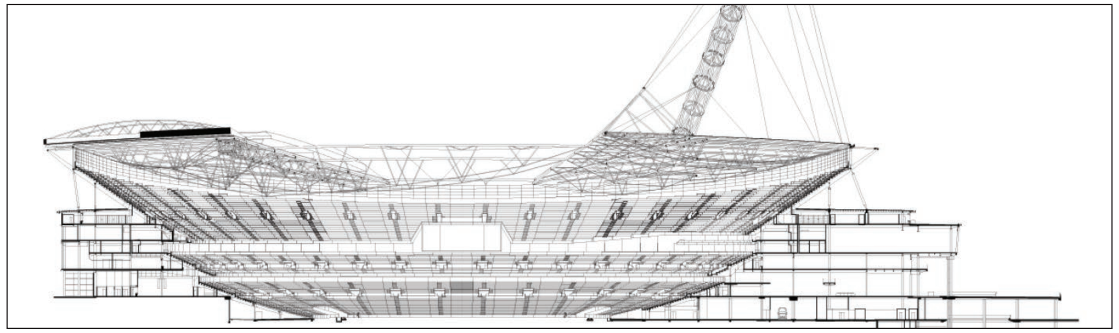


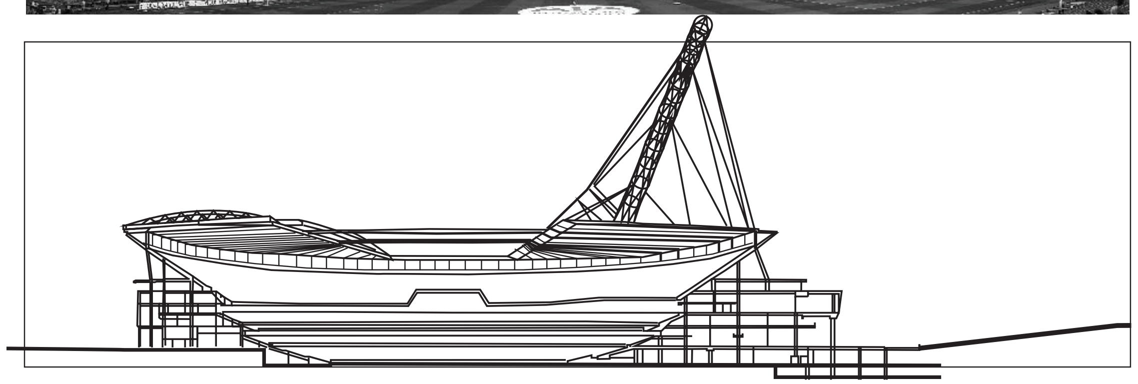
MONTREAL BIOSPHERE

LOCATION / DATE
Montreal, Canada 1967 AD

ARCHITECT
Buckminster Fuller

INNOVATION / DETAILS
Built for expo 67 it is now used as a interactive museum showcasing and exploring the water and ecosystems of the Great Lakes area.
Volume ~ 64.66 Million ft³



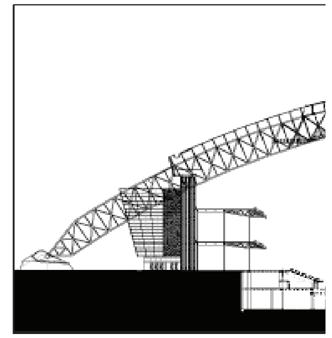


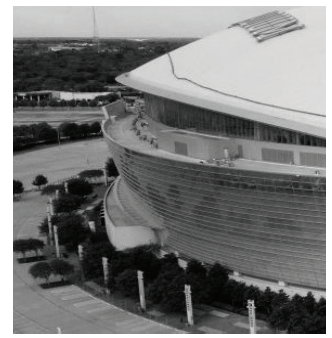
WEMBLEY STADIUM

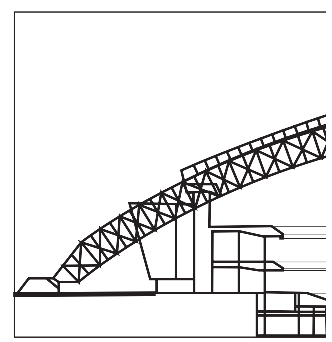
LOCATION / DATE
London, UK 2007

ARCHITECT
Nathaniel Lichfield, Foster & Partners, and others

INNOVATION / DETAILS
The Arch stands 436’ high and sits 22º off true and if the longest unsupported roof structure.
Volume ~ 40.22 Million ft^3





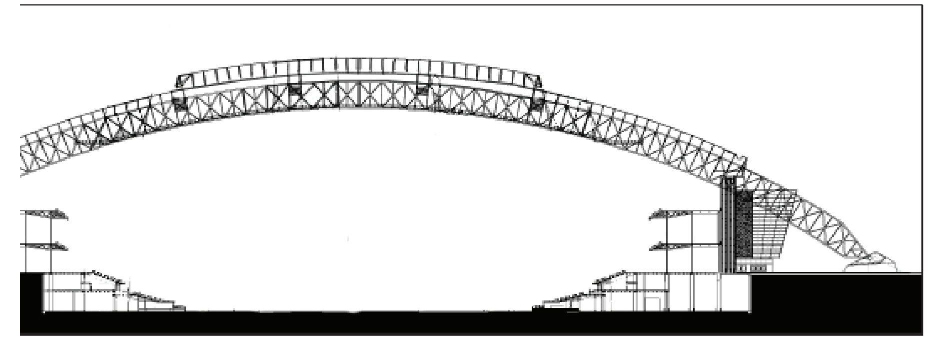


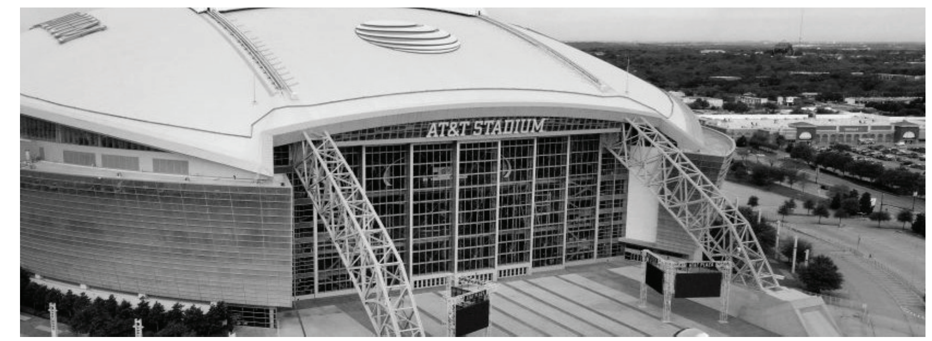
AT & T STADIUM

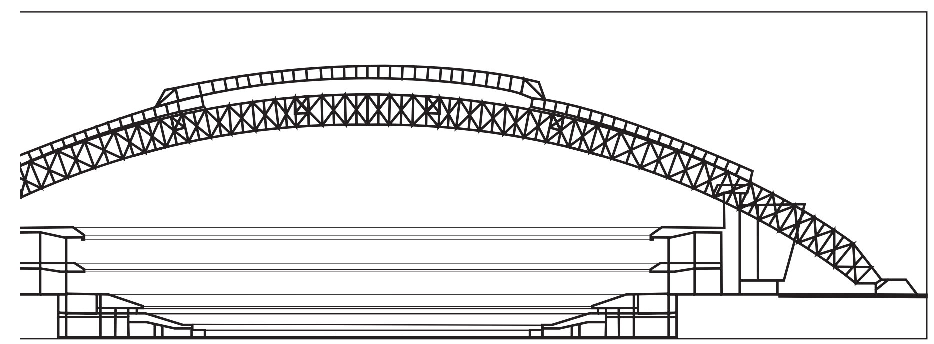
LOCATION / DATE
Dallas, Texas 200

ARCHITECT
Bryan Trubey, HKS

INNOVATION / DETAILS
Tallest dome in th
most expensive s
um ever built.
Volume ~ 104 Mill







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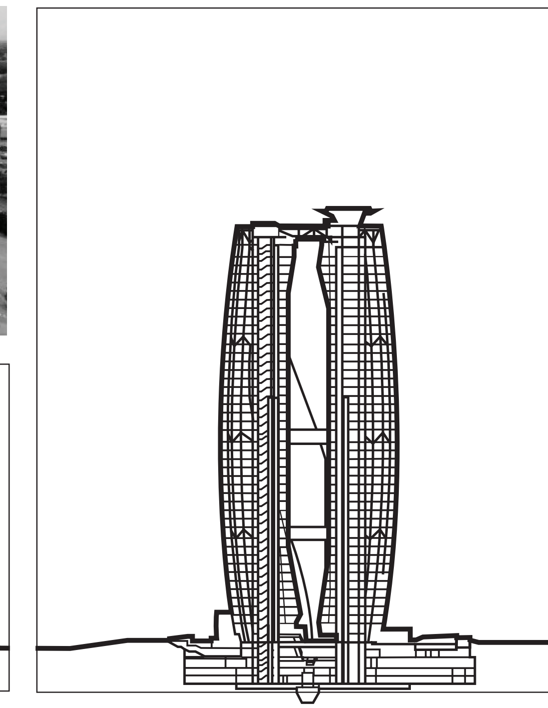


LEEZA SOHO

LOCATION / DATE
Beijing 2019 AD

ARCHITECT
Zaha Hadid
Patric Schumacher

INNOVATION / DETAILS
Worlds Tallest Atrium.
Volume ~ 29 Million ft^3


Image: (i32) Ziggurat at Ur

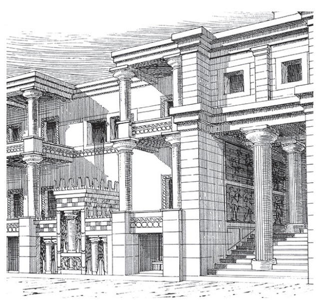


Image: (i33) West wing of Minoan palace complex at Knossos

I

The Future and Architecture

Chapter: 9 Hight

Many a reason has been made for building tall. In ancient times, chaos and information about the world people lived in was limited to provide stability and security; large structures were established to project strength and honor gods or kings. The monumentality of structures built this way persists to this day, along with added goals. While this chapter will focus on height achieved through specific means such as early arches used by Rome, then iron-based structures used by the people during the industrial revolutions of the 1800s, and finally advances in steel and concrete, it is essential to know what other large structures existed before them as precedence to them.

Early Hight

An Early Example is the Ziggurat. This ancient temple built by the earliest civilizations of Mesopotamia was meant to embody the strength of the gods and house the priests and priestesses of the upper class. The ancient Minoan palace complex Knossos was four stories tall astonishing for its time, and served as a royal religious and economic trade hub for the city. The colossus of Rhodes a true monument in the sense of the word allegedly built to commentate Rhodes' great victory over the *^%&.

Hight in Ancient Rome

Height in Rome can be odd at times, with some structures purely built for vanity while others serve a role in infrastructure and still others an economic. Today, what we would call a multi-family mixed-use is the precursor to modern high-rise apartment buildings in ancient Rome. In Rome itself and spread across the empire, many insulas existed: a commercial ground floor with anywhere from 1 to 7 stories of residential above. This innovation allowed Rome to become the greatest and largest populated city on the face of the earth at the time. Hight was also used on Capitaline Hill to convey the power of the later emperors of Rome. The hill itself started out as a neighborhood for Rome's wealthiest citizens. Eventually, it was completely taken over by the Roman emperor's ever-expanding palace complex, which carved out and around the hill, imposing itself on the rest of the city.

Many monuments of Rome also did the same; massive triumphal arches and columns elevated the deeds of emperors and generals. While public works like the coliseum created multi-storied facades that towed over the populace.

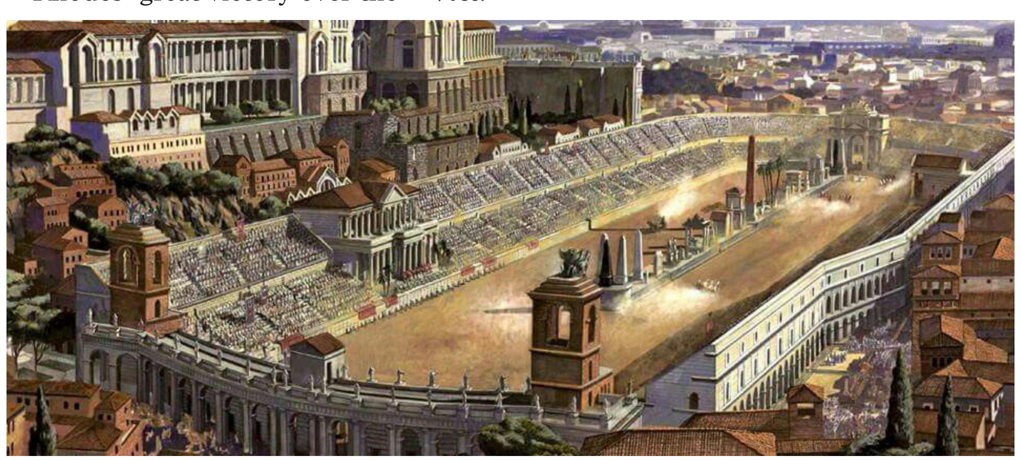


Image: (i34) Circus Maximus and Palace of Domitian 312 AD

References: (i32) Wikimedia Commons , (i33) Elite Minoan Architecture: Its Development at Knossos, Phaistos, and Malia , (i34) Yadegar Asisi

Iron Sky's

When thinking of the Industrial Revolution, one inevitably thinks of the Eiffel Tower. In a way, the tower started the general public's obsession with height and, while hated, initially opened many people's eyes to a new perspective, influencing many artists of that time. Taking inspiration for the prefabrication of some of the earlier industrial revolutions' exposition buildings, cast-iron facades as structure and decoration on the exterior of buildings saw great use, and it wasn't long until this was used on the inside of structures as well.

Many structures in new York and London used cast iron in their facades to create bigger openings and let more light deeper into their ever taller and broader structures.

During this industrial revolution era, hight focused on efficiency while still maintaining the idea of the classical facade and interior. This efficiency meant stacking as many people as possible in a workspace, whether a small factory floor in New York or an office tower like the empire state building.

Modern Hight

From the industrial revolution, iron-based structures evolved into steel and then steel and concrete soon after. Skyscraper design in this early modern era was dominated by stone clad facades hiding the structural grid of steel behind it. However, better methods where invented structures became varied in actual type from all steel to steel and concrete, tube in tube, and even reinforced concrete. Nowadays, high rise structures are mainly mixed structurally to provide paths for necessary forces only, and over engineering has been phased out entirely due to the advent of the specialized structural engineer.

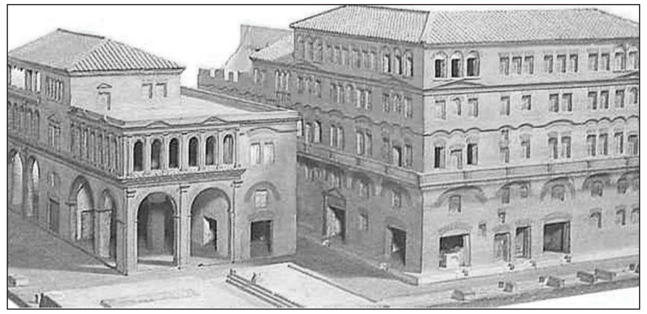
In most Tower designs, the architect only chooses a structural system and designs a facade to work with it. For the interior, the architect only designs the interior and several other areas of the building and rarely does every floor individually.

Modern height, in general, is still focused on efficiency. It isn't about it as a complex of the same volume would be cheaper if built in the suburbs after clearing a forest and using most of the space for parking, such as Stalantis's Auburn Hills headquarters. Thusly modern skyscrapers focus on trying to create a tower to showcase the wealth of the corporations and banks funding them. Serving as more of a status symbol than trying to practically fit everyone in a building. For this reason, many current-day skyscrapers have a residential, commercial, and hotel aspect to them. Generally layered out so that the base of the structures are commercial, followed by some office space, then residential, then a hotel function, followed by either penthouses or restaurants at the top.


Image: (i36) 1931 Empire State Building


Image: (i35) Chrysler World Headquarters and Technology Center in Auburn Hills, Michigan

References: (i35) https://media.stellantisnorthamerica.com/image-gallery.do?method=adhoc&mid=&imageIds=,26330,26332,26334,26331,26333 , (i36) mashable

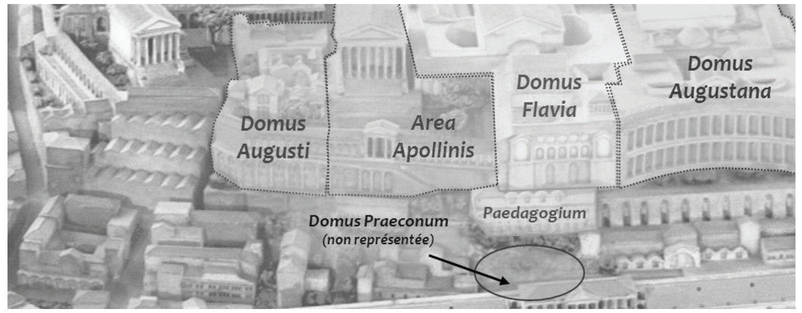


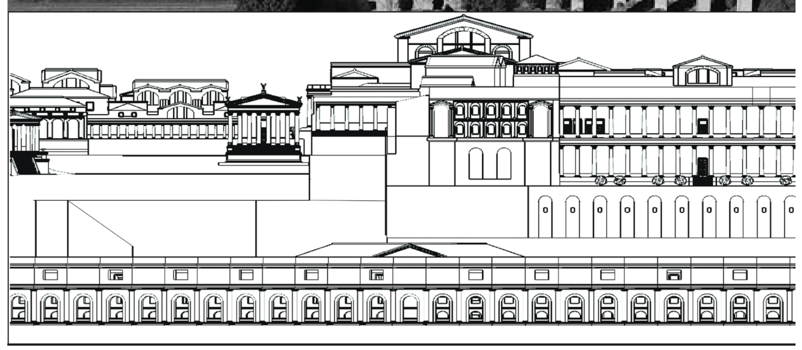
ROMAN INSULA

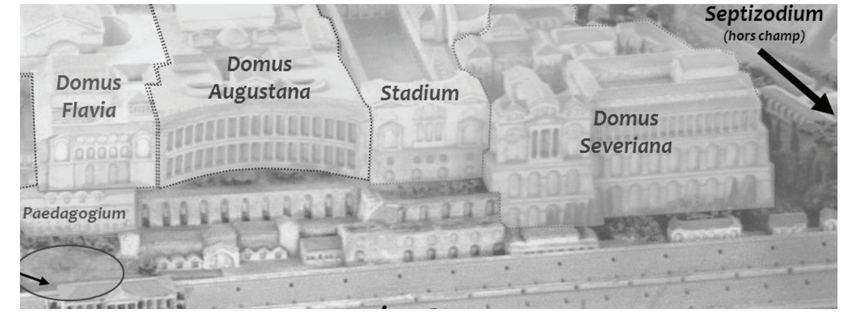
LOCATION / DATE
Imperial Rome 50 BC - 300 AD

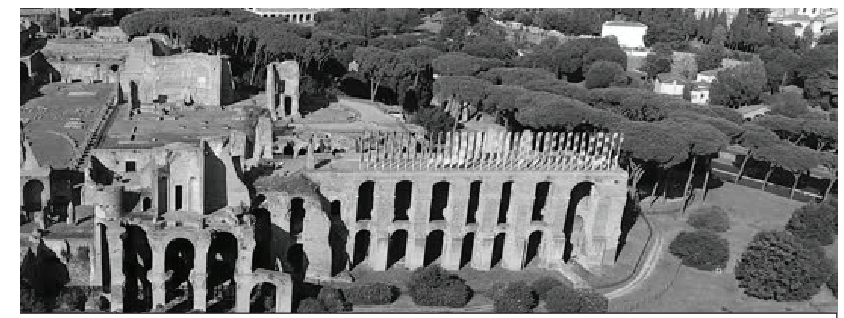
ARCHITECT
Many and unknown.

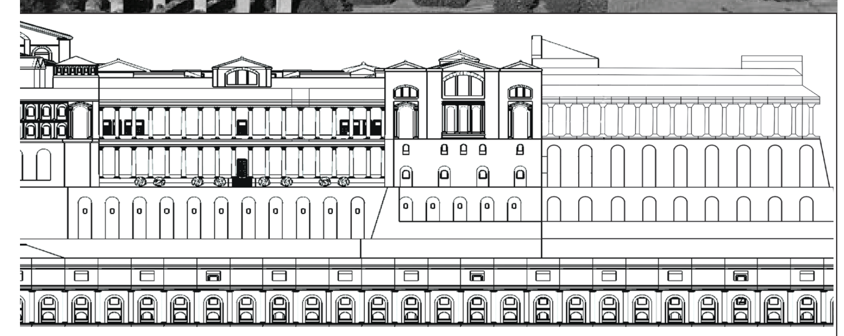
INNOVATION / DETAILS
The basis of all modern multi-family / mixed use structures. The first time that a structural type was fully copied on this scale. Height 70'











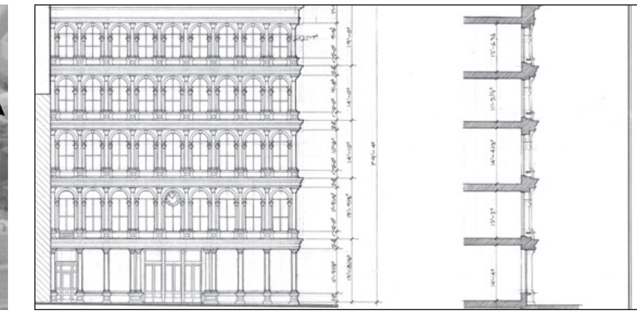
PALATINE HILL

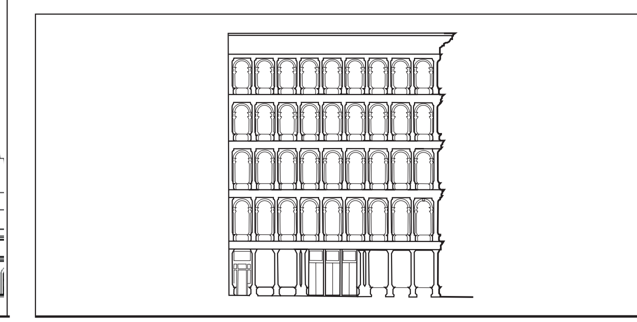
LOCATION / DATE
Rome 30 BC - 70 AD

ARCHITECT
Rabiria gens Gaius Caprarius
Scopas Bupalus Athenis

INNOVATION / DETAILS
First place people Settled in Rome.
Height 230'

Rome.





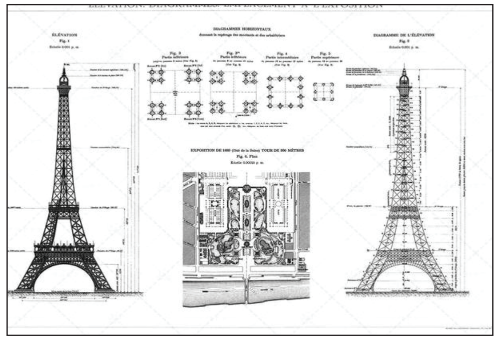
E.V. HAUGHWOUT BUILDING

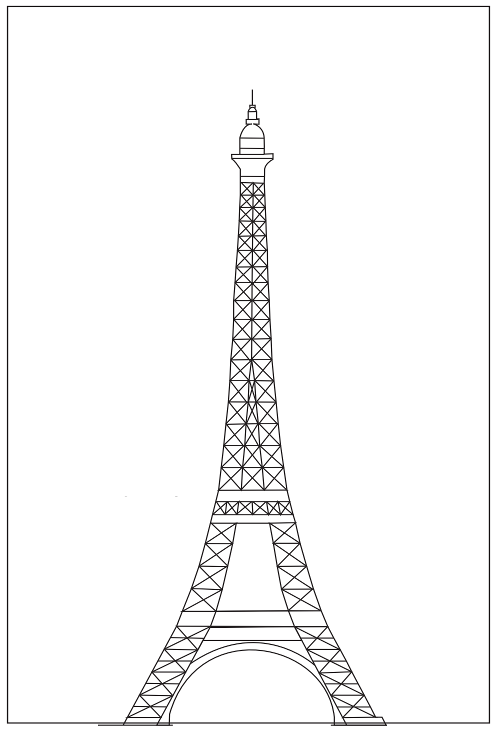
LOCATION / DATE
New York City 1857 AD

ARCHITECT
John Gaymor

INNOVATION / DETAILS
First cast iron facade to be used as its structure. The first skyscraper. Held the first ever elevator.
Hight 79'

Monumental Height



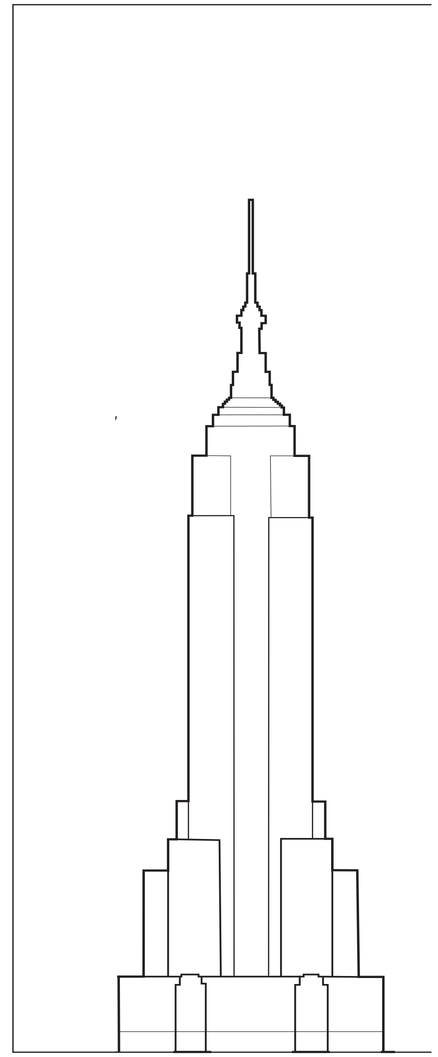


EIFFEL TOWER

LOCATION / DATE
Paris 1889 AD

ARCHITECT
Gustave Eiffel

INNOVATION / DETAILS
The tallest man made structure for 40 years. Height 1,063’

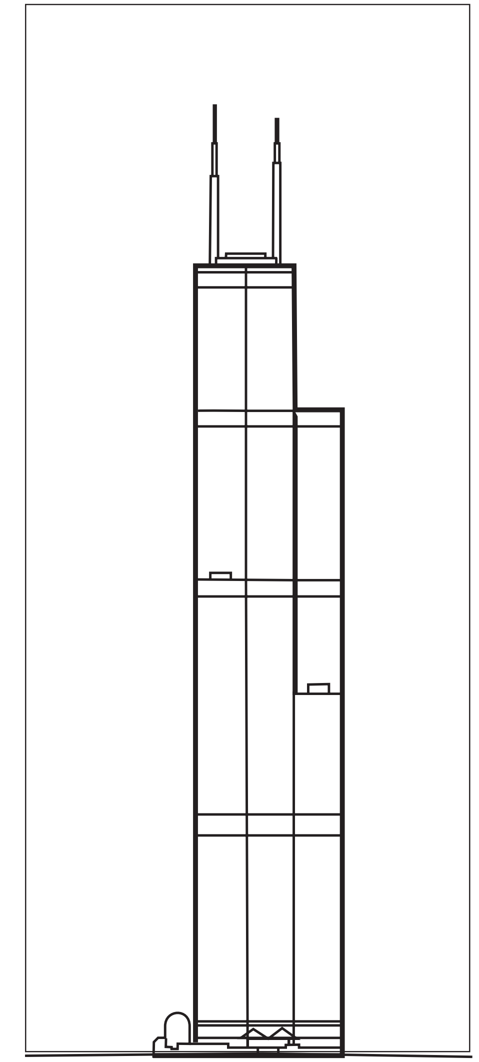


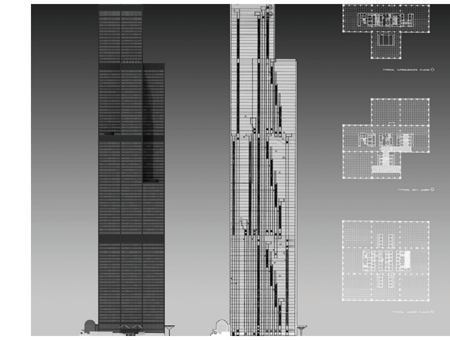
EMPIRE STATE BUILDING

LOCATION / DATE
New York City 1931 A

ARCHITECT
Shreve, Lamb & Harmo

INNOVATION / DETAILS
Tallest building in t
world for 42 years. Fi
building with over 1
floors. Height 1,454’



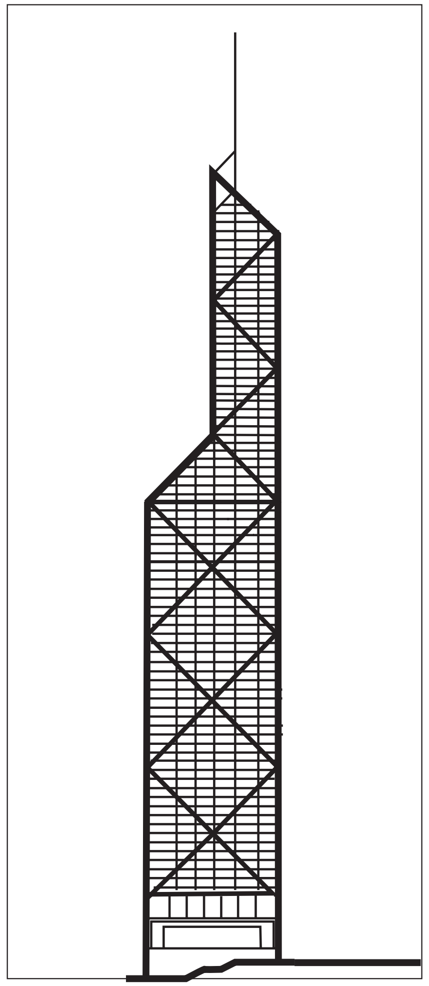


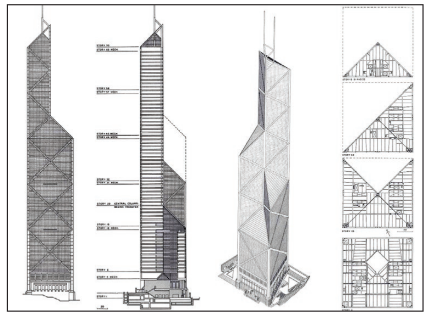
WILLIS TOWER

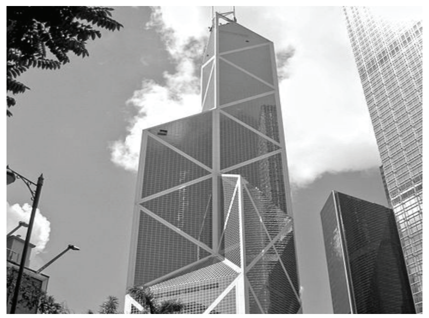
LOCATION / DATE
Chicago 1974 AD

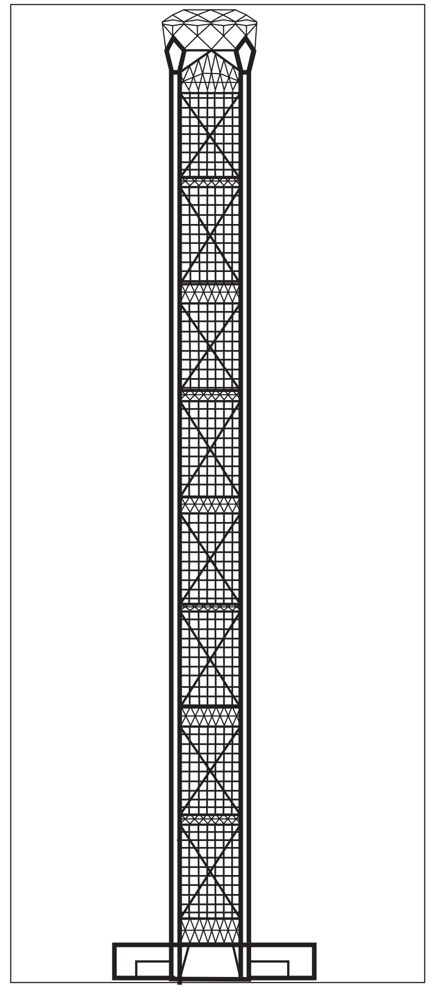
ARCHITECT
Fazlur Khan
Skidmore Architects

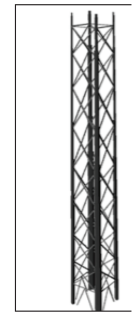
INNOVATION / DETAILS
The tallest structure for 25 years and first Bundled tube structure. Height 1,729’











BANK OF CHINA TOWER

LOCATION / DATE
Hong Kong 1990 AD

ARCHITECT
I. M. Pei

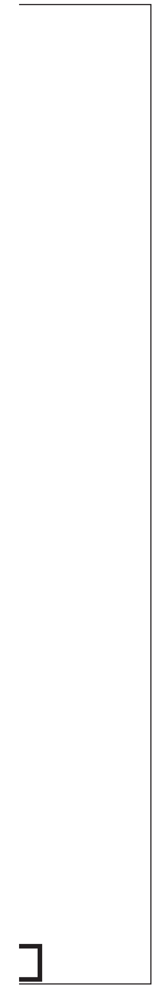
INNOVATION / DETAILS
The first Space Frame structure and the first building outside the US to surpass 1,000'
Height 1,205'
Tianjin

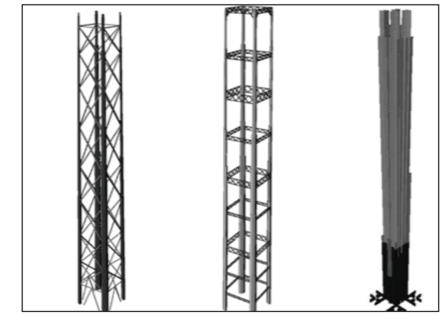
GOLDIN FINANCE 117

LOCATION / DATE
Tianjin, China

ARCHITECT
P & T Group

INNOVATION / DETAILS
The tallest flat roof building and first use of braced megatubes in a building. Height 1,916'





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it roof
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es in a
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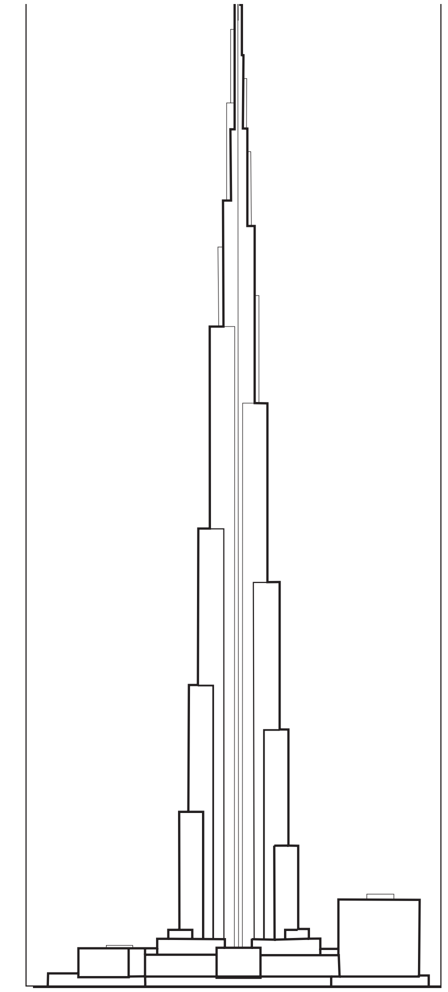
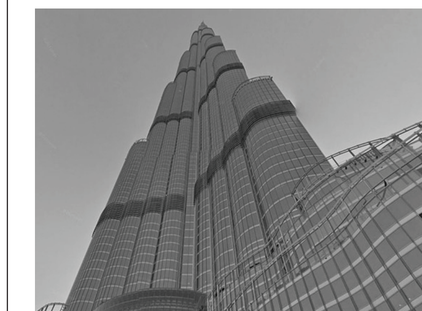




BURJ KHALIFA

LOCATION / DATE
Dubai, UAE 2010 AD

ARCHITECT
Adrian Smith
Skidmore architects

INNOVATION / DETAILS
The tallest structure ever built. 15 Records
Height 2,722'

I

The Future and Architecture

Chapter: 10 Magnetics and Architects

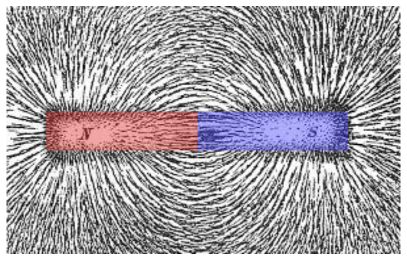


Image: (i37) Magnetic Field

What does history have to do with magnets? The last section focused on the history of structures throughout human history to provide examples of why people built what they built and how. It showed how humans dealt with changing structural innovations and how they were used to better the lives of those that created them. Technology and thusly magnets have much the same progressively orientated history.

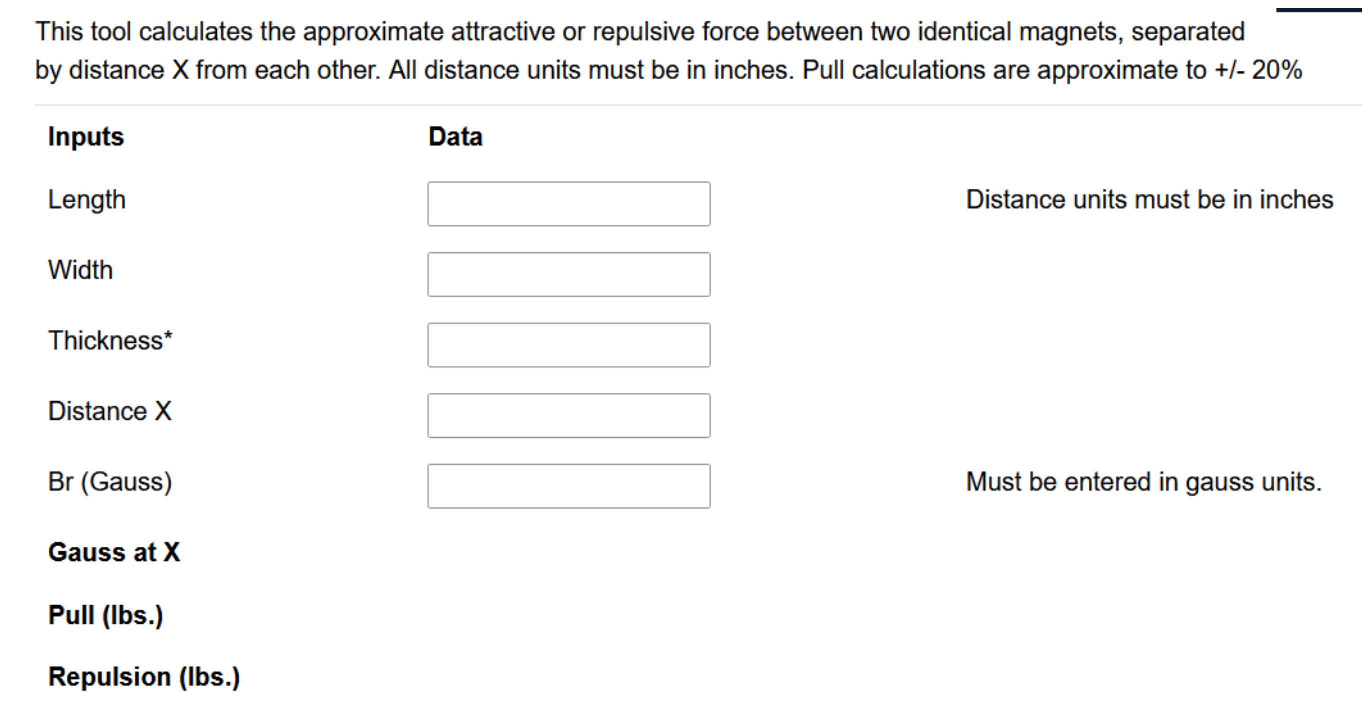
Magnets have a long-standing relationship with motors and power generation. In fact, every car and power station in the world uses magnets. Cars use magnets in several ways to start, recapture energy, and convert electrical power to mechanical are just a few. Power stations use magnets to change rotational energy to electrical energy. Almost all power stations use a steam turbine system in the final power production phase. This isn't the only way magnets are connected to power; however, electricity and current produce a magnetic field.

Architects, in this way, can only ever deal with magnets when designing. In most situations, architects do not even consider any magnetic properties that any structure might admit as any structure that would have magnetic equipment would have specialists in that field involved, such as if an architect designed a power station, specialized personnel hired would deal with and know power equipment better then the architect and would just convey the dimensions of the equipment to the architect to build the space around.

Architects working with nature is a relatively new concept and a flawed idea, albeit not something every architect shouldn't strive for but an impossible goal. Architecture, by its very nature, is against nature; we strive to construct shelter from it and control it after all. Even the earliest and simplest architecture that most people would say is in tune with nature, in reality, it isn't. the simple native hut built of sticks and pelts in a way also interrupts the natural cycle. By collecting sticks, the natives disrupt the natural breakdown of that stick into the dirt, thus starving the local environment of nutrients. The same can be said of the pelts, as animals were removed from existence to construct the shelter, thusly disrupting the food chain. All this culminates in the idea of the apex predator, the human predator. Other animals do this as well. The humble bird eats insects and scavenges material for nests to raise its young. It is only natural for humans to use their resources to better themselves. What isn't natural is the ability to hinder our own species' growth by limiting what we can and can not use.

In a way, the destruction of nature is nature itself, as we are part of this world too.

References: (i37) https://www.explainthatstuff.com/magnetism.html



This tool calculates the approximate attractive or repulsive force between two identical magnets, separated by distance X from each other. All distance units must be in inches. Pull calculations are approximate to +/- 20%

Inputs	**Data**	
Length		Distance units must be in inches
Width		
Thickness*		
Distance X		
Br (Gauss)		Must be entered in gauss units.
Gauss at X		
Pull (lbs.)		
Repulsion (lbs.)		

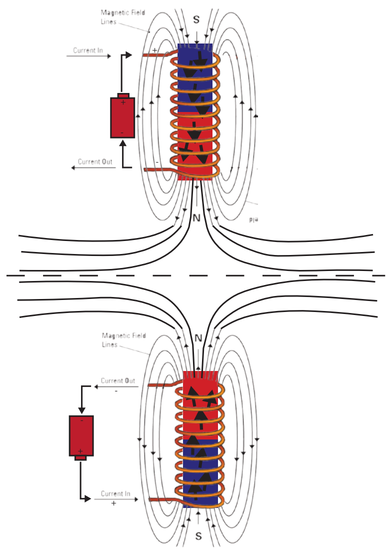
Image: (i59) Online Tool used When testing calculations

References: (a) https://www.intemag.com/magnet-push-or-pull-calculations-between-rectangular-magnets

I

The Future and Architecture

Chapter: 11 Strengths & Weaknesses



1 Maxwell's equations

Maxwell's equations may be written in differential form as follows:

$$\nabla \cdot \vec{D} = \rho, \quad (1)$$

$$\nabla \cdot \vec{B} = 0, \quad (2)$$

$$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}, \quad (3)$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}. \quad (4)$$

The fields $\vec{B}$ (magnetic flux density) and $\vec{E}$ (electric field strength) determine the force on a particle of charge q travelling with velocity $\vec{v}$ (the Lorentz force equation):

$$\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right).$$

The electric displacement $\vec{D}$ and magnetic intensity $\vec{H}$ are related to the electric field and magnetic flux density by the *constitutive relations*:

$$\vec{D} = \varepsilon \vec{E},$$

$$\vec{B} = \mu \vec{H}.$$

The electric permittivity ε and magnetic permeability μ depend on the medium within which the fields exist. The values of these quantities in vacuum are fundamental physical constants. In SI units:

$$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{Hm}^{-1},$$

$$\varepsilon_0 = \frac{1}{\mu_0 c^2},$$

where c is the speed of light in vacuum. The permittivity and permeability of a material characterize the response of that material to electric and magnetic fields. In simplified models, they are often regarded as constants for a given material; however, in reality the permittivity and permeability can have a complicated dependence on the fields that are present. Note that the *relative permittivity* ε_r and the *relative permeability* μ_r are frequently used. These are dimensionless quantities, defined by

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}, \quad \mu_r = \frac{\mu}{\mu_0}. \quad (5)$$

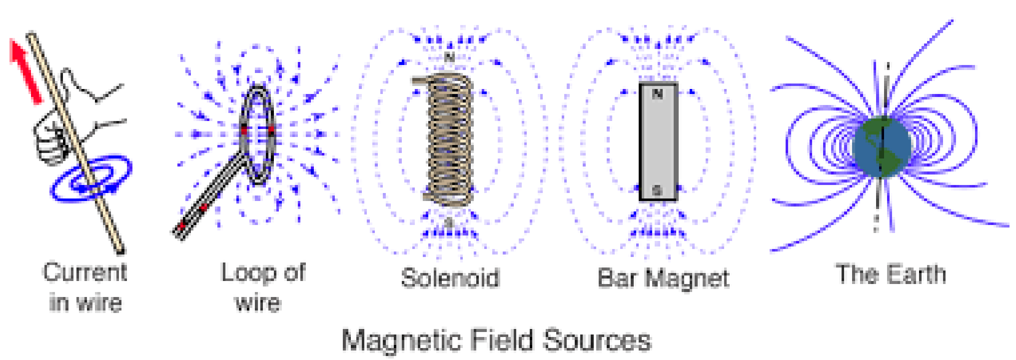


Figure: (f10) Possible Magnetic Field Sources

References: (f10) R Nave , Wolski, A. pp. 1–51, Theory of Electromagnetic Fields.

The Strengths of Magnets

The strength of magnets lye in its magnetic field emitted. The magnetic field is this alignment of electrons, which is emitted from the magnet. The field itself is incredibly powerful near the point of origin and gets increasingly weaker as the distance is increased. In fact, the strength of the magnetic field is inversely proportional to the distance from the magnet, which can be seen in the formula below for calculating magnetic fields.

The two poles of magnets hold the power of attraction and repulsion, both of which use the same formula, although repulsion has additional steps after figuring out field strength, which involves taking into account the mass and gravity of the object being levitated. This magnetic field cannot be fully penetrated, and in fact, if you would force two magnets of the same pole together and force them to touch, while you think they are touching, they are not; you just can't see it.

The interaction of magnetic fields and material is also of great note. The ability to attract certain objects, as stated before, is ferromagnetic and non ferromagnetic. This ability to attract or completely ignore is an ability that is abused by many different objects and technologies. That being said, all matter has slightly different interactions with magnetic fields; this is called the diamagnetic. Metals, for example, have a higher tendency to be attracted to magnets while gases and liquids, for the most part, do not. This means extremely high-powered magnets can be used in the atmosphere and underwater with little to no effect on strength depletion.

The Weaknesses of Magnets

Of the two types of magnets discussed in this book, regular magnets and electromagnets, both having different material weaknesses. Regular magnets are structurally fragile and can chip or shatter easily. They are susceptible to changes in temperature, which can further change their material stability and affect field strength negatively if the temperature gets too high. This temperature change can be naturally applied by outside forces or generated through intense use under extreme pressures. Electromagnets are similar when looking at the temperature aspect. Still, materially they are, as discussed before, typically copper wire around a core, usually soft iron, both of which can deform under pressure. An accident at CERN shows what can happen to a magnetic component if something goes wrong; in this case, the entire structure twisted itself at 30 degrees down angle.

Another weakness is related to one of its strengths, the field limits. While it can provide a great boon to uses also provides the upper limit of usability in atmosphere and water. If field strength exceeds a particular point then atmospheric ionization can occur where ions are stripped off the various gases and create deadly Ozone. This happens on earth naturally in the form of the northern lights however requires magnetic fields that far exceed anything that has been produced yet. This can also occur with any material at specific points; however, most have magnetic tolerances that are on par if not near the resistance of the atmospheres.

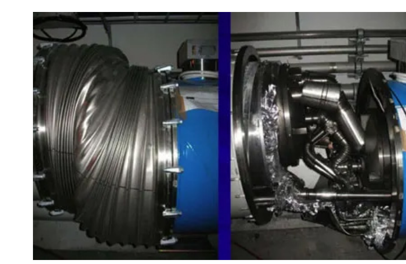


Image: (i38) LHC at CERN region between two magnets in the LHC that was crushed

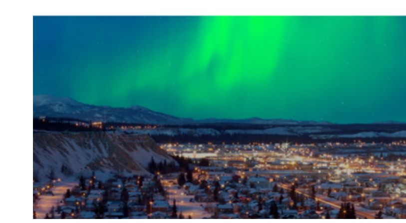


Image: (i39) Northern lights over downtown Whitehorse

References: (i38) 2008. Photograph: Public Domain , (i39) Pi-Lens/iStock/Getty

As stated before, reputation requires additional equations involving gravity mass and distance between the two opposing magnets.

Large scale magnets like those at CERN set a precedence for the kinds of scales it would take to levitate structures of a decent size. It is fully recommended that an on-site power generation is available and multiple backups with the ability to lower the structure if anything goes wrong such as fire.

As mentioned before, the magnetic output is vastly affected by temperature, and generally, the higher the temperature, the weaker the field's output. Not only that, but magnetics also become structurally unstable at higher heat, tending to crack or melt under certain circumstances. Electromagnets especially produce vast amounts of waste heat when under heavy loads due to the energy passing throughout the coils. When interacting with certain objects, the magnetic field can heat them to some small degree. On a large scale, CERN solves this with the world's largest cryogenic systems, allowing it to cool the millions of powerful electromagnets in the LHC.

Image: (i40) liquid helium cryogenics at CERN

Given the above concerns, large cryogenic systems must be installed in any building using large high-power magnetic levitation systems. Routed not only through the magnetic systems but the computers controlling them as well.

References: (i40) Maximilien Brice, CERN

1 Maxwell's equations

Maxwell's equations may be written in differential form as follows:

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$$\varepsilon_0 = \frac{1}{\mu_0 c^2},$$

where c is the speed of light in vacuum. The permittivity and permeability of a material characterize the response of that material to electric and magnetic fields. In simplified models, they are often regarded as constants for a given material; however, in reality the permittivity and permeability can have a complicated dependence on the fields that are present. Note that the *relative permittivity* ε_r and the *relative permeability* μ_r are frequently used. These are dimensionless quantities, defined by

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}, \quad \mu_r = \frac{\mu}{\mu_0}. \quad (5)$$

Guass's theorem states that for any smooth vector field $\vec{a}$,

$$\int_V \nabla \cdot \vec{a}\, dV = \oint_{\partial V} \vec{a} \cdot d\vec{S},$$

where V is a volume bounded by the closed surface ∂V. Note that the area element $d\vec{S}$ is oriented to point *out* of V.

Gauss's theorem is helpful for obtaining physical interpretations of two of Maxwell's equations, (1) and (2). First, applying Gauss's theorem to (1) gives:

$$\int_V \nabla \cdot \vec{D}\, dV = \oint_{\partial V} \vec{D} \cdot d\vec{S} = q, \quad (6)$$

References: (a) Wolski, A. pp. 1–51, Theory of Electromagnetic Fields.

I

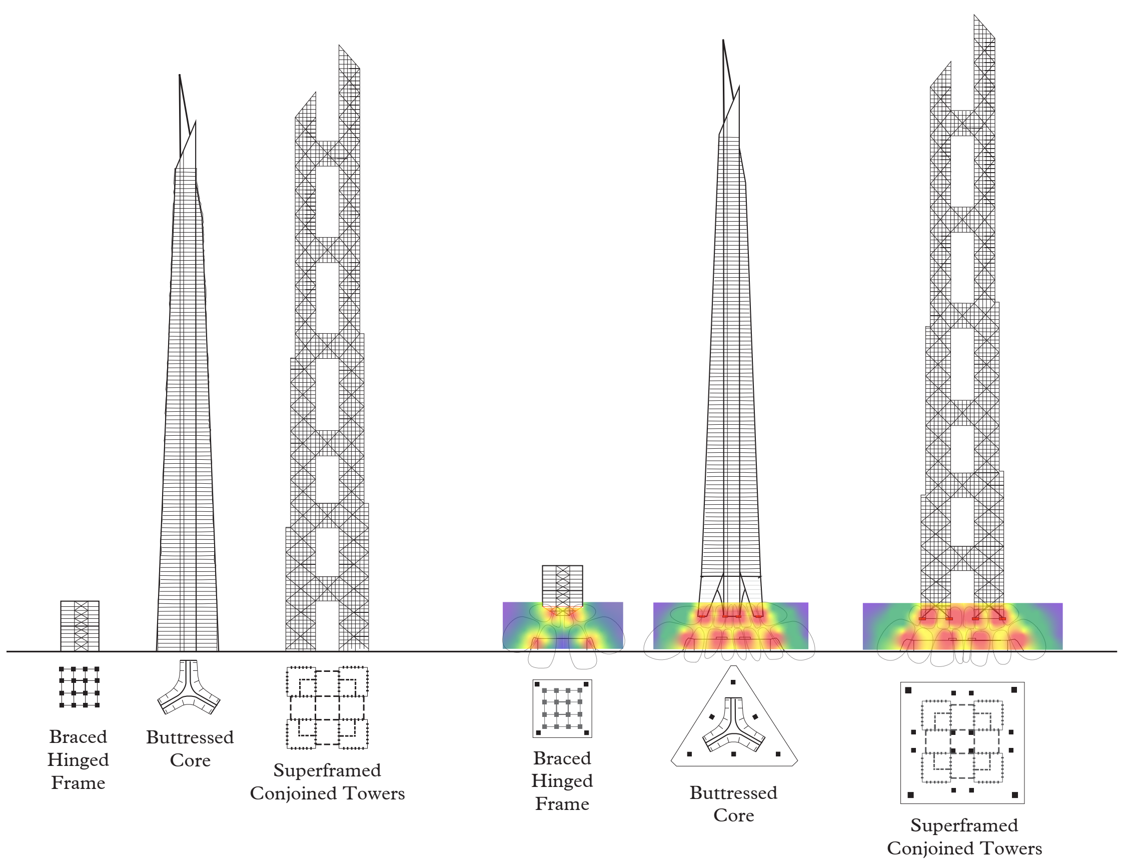
The Future and Architecture

Chapter: 12 Magnetic Strengths

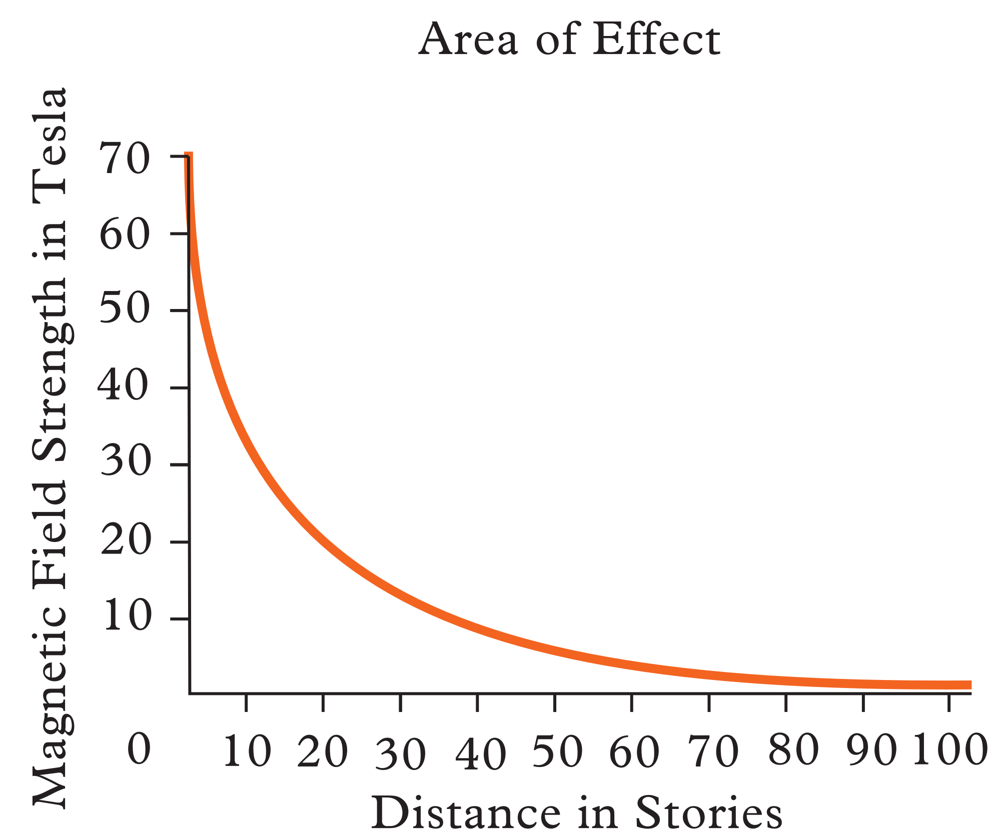
The Scale of the Field

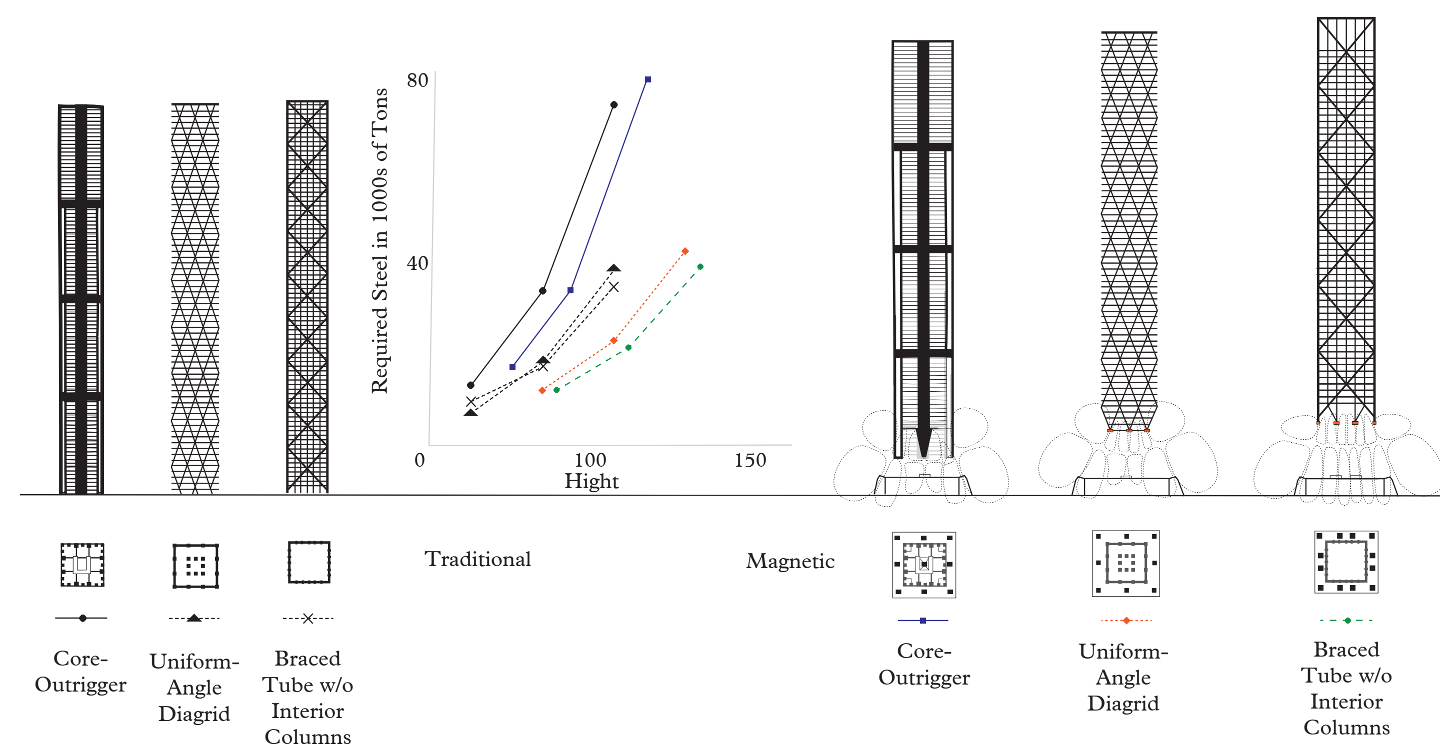
The field's scale depends on distance and current input and can vastly affect the habitable area in and around a structure using them. Not only is the site in and around uninhabitable, but only strategically placed and aligned ferromagnetic material should be placed inside the uninhabitable zone to reduce the risk of the structure tarring itself apart. This also means that all support machinery from power generation, computers, and cryogenic rooms should be located at a safe distance but still within proximity of the system as DC power is required to power the main electromagnetic systems

The Strength of the field can also cause problems for those with heart monitors or heart pumps, so entrances to structures should be far enough away and elevated above the field. Some animals may be affected as well; having biological compasses in some of their brains can mess with their ability to migrate properly and could potentially harm or kill them. Thusly it is imperative that large systems installed in water be netted off or sunk into silt to protect any local ecosystems that could be affected. Unintended side effects are inevitable with new technology, and it wouldn't be a surprise if something else also cropped up in another field entirely.



References: (a)





References: (a)

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The Future and Architecture

Chapter: 14 Power

The Power Problem

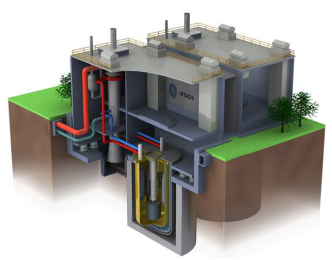


Image: (i41) A cutaway of the PRISM design for a SMR

Power input, as mentioned before, is a significant issue. Currently, it is incredibly impractical to levitate even a relatively small structure. As stated in a previous chapter, the world currently faces a power crisis that threatens global climate stability. This, however, should solve itself shortly as there are many options for clean energy.

Complain about putting this poisonous substance in the ground. This, however has been thought of thoroughly and many countermeasures are in place to protect and prevent access to it for literally millions of years.

If that wasn't enough, recent studies have found ways to use the spent fuel as a fuel itself, allowing it to be used up and creating a safe byproduct from it completely.

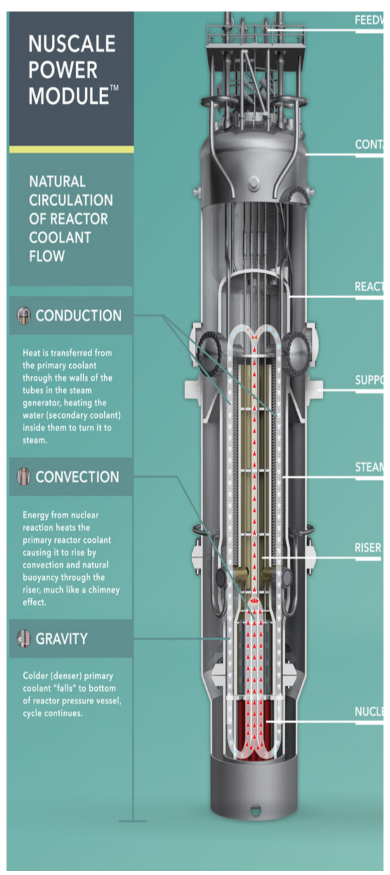


Image: (i41) A cutaway of a small module Reactor SMR designed by NuScale

The nuclear options are vast and complex. While most of the general populous shy away from nuclear as a viable power source due to the accidents of past decades, the truth is nuclear is the safest and most sustainable option. Those various accidents that people give as a reason for not wanting nuclear are the very reason it is so safe. The accidents themselves created new regulations and safety measures to be put in place across the entire nuclear community. With literally hundreds of safety measures and emergency shutdown procedures, it is impossible to recreate any disaster from the past, such as Chernobyl or Kyoto. This is true for the general technological safety systems and is also achieved by using safer, less volatile uranium fulls.

The other significant complete about nuclear is the treatment of the waste, and while a valid complaint in the past, that is no longer the case. With the recent opening of the nuclear waste disposal facility in Sweden and the plans for two more in Canada and the USA, waste disposal is no longer a problem. However some still

The evolution of solar power has been increasing as NASA, among other corporate entities, has released better and more efficient solar panels over the last few decades. This trend will undoubtedly continue until maximum efficiency is reached.

References: (i41) PRISM design (GE Hitachi) , (i42) NuScale Power of the United States

Geo-thermal is a viable power source that some structures already operate interdependently of the grid. Usually, built in the bottom of structures is preferred for the deeper independent foundations that can be tunneled below the earth for the magnetic systems to be powered off.

Image: (i44) Processing Technology of Neodymium Magnets

Tidal systems could also be installed on the waterside electromagnet levitation systems; although not a great strategy for generating a large amount of power, it could serve as a supplement.

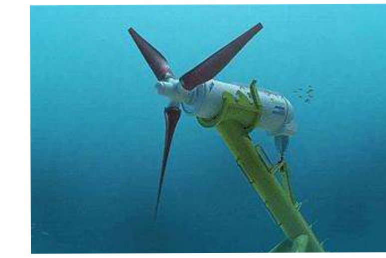


Image: (i43) Tidal Energy turbine

Like a hospital relies on power to keep some patients alive and thusly has vast amounts of emergency backup generators, structures using electromagnets to levitate would need to have massive backup systems and backups for those backups.

Supercapacitors are a recent power storage device. They can be used to store large amounts of power for extreme amounts of time with no loss and release that energy incredibly quickly. While the speed of the release of the energy does not affect the use of electromagnets, it would have to be slowed and spread out using a variety of step-downs. Supercapacitors would still make for a great way to store power in a backup system without having larger systems.

Image: (i45) Hospital Generators

References: (i43) Andritz Hydro Hammerfest , (i44) https://www.stanfordmagnets.com/processing-technology-of-neodymium-magnets.html , (i45) https://csdieselgenerators.com/hospital-generators/

I

The Future and Architecture

Chapter: 15 Material Research & Extraction

Material in depth

Ordinary magnets are made of combinations of rare minerals, many of these can be found all over the world, but most currently come from China; while Africa and the US hold vast amounts of untapped rare earth elements, it is safe to say some are locked forever beneath protected national parks and private property.

Electromagnets, however, use Paramagnetic material as a core to the copper coil, the most common of which is iron, which we will most certainly never run out of as it is one of the most common metals in the universe. This isn't the only thing that can be used; however, CERN, for example, uses experimental superconductors, which are made from various compounds through extremely complex chemical and meteorological processes.

Image: (i46) Rare earth element mine

Mining and processing of these materials are no different from any other that is incredibly destructive to the environment. However, this destruction is frowned upon is necessary for human development and will inevitable one day completely cease, as we will see why that is in a later chapter.

Processing for magnets varies with the type; as stated before, pure iron cores for electromagnets are the most common, but the incredible complex also requires large vasts presses and dyes and specialized vacuum kilns produced on the scales needed.

Untapped US resources could lower the cost of some of these materials. But overall, better manufacturing processes will ultimately drive the coast down.

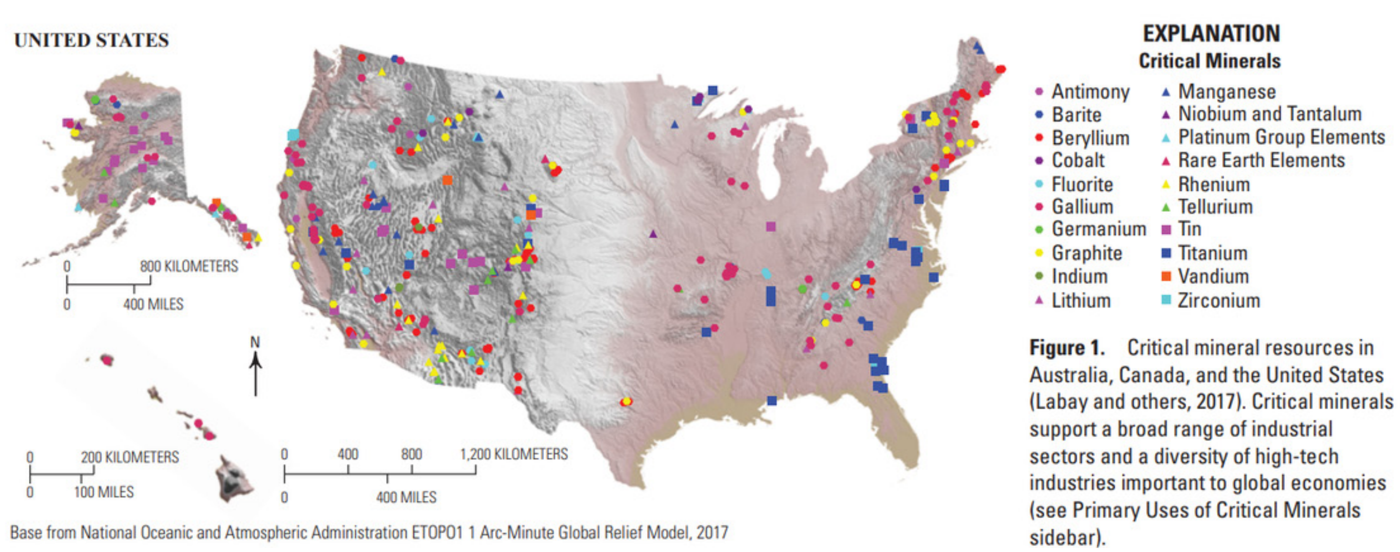


Figure: (f11) Current Rare earth element mine across the USA

References: (i46) https://www.duramag.com/techtalk/rare-earth-magnets-2/rare-earth-mining-revival/ , (f11) National Oceanic and Atmospheric administration

References: (a)

II
Criticisms
Chapter: 16 Problems and Solutions

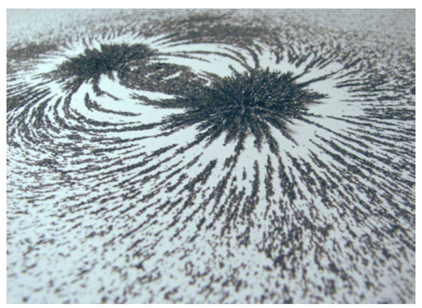


Image: (i47) Magnetic Field

The basics of field danger can be broken down as follows, The danger of the intensity and area of the effect of the field and its effects on its surroundings, and the threat of power loss. Throughout the first half of this year-long thesis program, this thesis focused partially on finding all of these possible threats inside these two categories. The second half of the year was spent finding solutions to those problems.

Metal in and around the structure was of particular concern; as such, it is suggested that all structural elements in and around the magnetic apparatus be of nonmagnetic properties and if any are or have to be magnetic, be orientated as such as to be allowed to align with the field. This would be most likely in a radiating fashion.

An example would be re-bar in concrete, perhaps should be allowed to align with the magnetic forces so as not to rip them from the concrete. Think of iron filings aligning to a magnet but replace the iron filings with a re-bar and air with concrete.

Human interaction should be avoided at close proximities at all coast. A distance should be calculated for safety using the inverse square of the strength of the field to determine the distance.

For example, an aluminum-framed structure weighing some amount but lighter than most, about 50 x 50 feet floating 20 feet off the ground, should have an entrance about 35 feet above the base of the floating structure. That is to say, 55 ft of the 70 ft max height.

Humans with heart monitors or pumps or with life-sustaining internal machinery should be safe at that distance, but further testing may prove otherwise, so even farther entry setbacks may be necessary.

Animals in and around the structure may be affected. Especially any migratory animals, as some have small magnetic particulates inside their bodies to help navigate north or south depending on the season. These high-power magnets will affect this pattern. Any built structure should seek knowledge of local migratory patterns and plan accordingly by considering a different site if needed.

Known animals at risk are various birds, insects, whales, and various fish species.

Interaction with radio, Internet, and cell will be affectively cut off around the structure's base, up to a higher percentage of the structure than just the inversely squared portion.

Power loss is a serious problem both in planning and in public opinion. Media for the first few buildings of this kind will always be against it, as is the nature of people, to fear what they do not understand. People still fear nuclear even though more radiation is released through coal burning than through nuclear sites over their life span. This fear will be prevalent in the first few structures built, but as the technology is better understood, so will the builds be better accepted by society.

The issue of power loss should be addressed by creating a structure with its power source supplemented by the grid and then backed up by no less than two other generators and two other battery's.

Heating and cooling is another issue, as before a cryogenic system must be installed for cooling purposes; as an aside, if the only objective is to cool the magnets, then other methods might also do, such as quantum cooling, which involves a piece of scaled-up chemistry equipment.

References: (i47) Windell Oskay

This cooling, as stated before, is necessary for the magnets and computer equipment but can also be necessary as per the environment.

Ionization of the atmospheres was mentioned before but can only be a threat for the extensive fields exceeding a given limit. This limits the size and weight of structures to less than 2 miles tall when at a reasonable width and uses super materials that are light weight. This problem most likely will not be seen for the next few decades, so it is of little importance.

Some materials known as Ferromagnetic materials, even at CERN are used to redirect magnetic fields. These can be used in structures to help lessen the existent of the field, creating a smaller inhabitable zone. Other materials still can partially reflect magnetic fields and can be used as shields to block portions of the field, further limiting the inhabitable zone's size.

This could reduce the size of the field by around 20 percent, depending on relatively smaller levitating structures.

Maintenance on such structures should be done only when the structure is in its lowered position and off. Any design that cannot be lowered should have some form of scaffolding that can be erected and used to prop up the structure temporarily.

When constructing any electromagnetic systems that have been directly anchored to bedrock, they tight and be internally pressurized, with airlock and tunnel access to the surface. Tunnels to the bedrock foundation systems should be large enough for modular equipment to be broken down and replaced.

Foundations should always strive to spread the load as much as possible. Magnetic fields should always be set at an angle dependent on the room available but shouldn't exceed 45 degrees off the center line of the structure's height. Upper magnets should be allied perpendicular to the center lower foundation magnets.

Foundation piles should be driven into bedrock deep and be condensed at the point of structural contact with the ground and magnets.

All structural loads should be driven to pints in the upper levitating structure, allowing the magnetic systems to transfer the full load of the building.

The electromagnets will most likely be in an array, that is to say, most likely be a series of smaller magnets connected in a system. This system will most likely have a structural carriage that it sits within. The carriage should be made to allow the transfer of the point load to spread to the upper portion of each of the electromagnets.

For smaller structures that can be raised during construction can occur at ground level, and the structure can be raided on opening day.

Image: (i49) Lightning

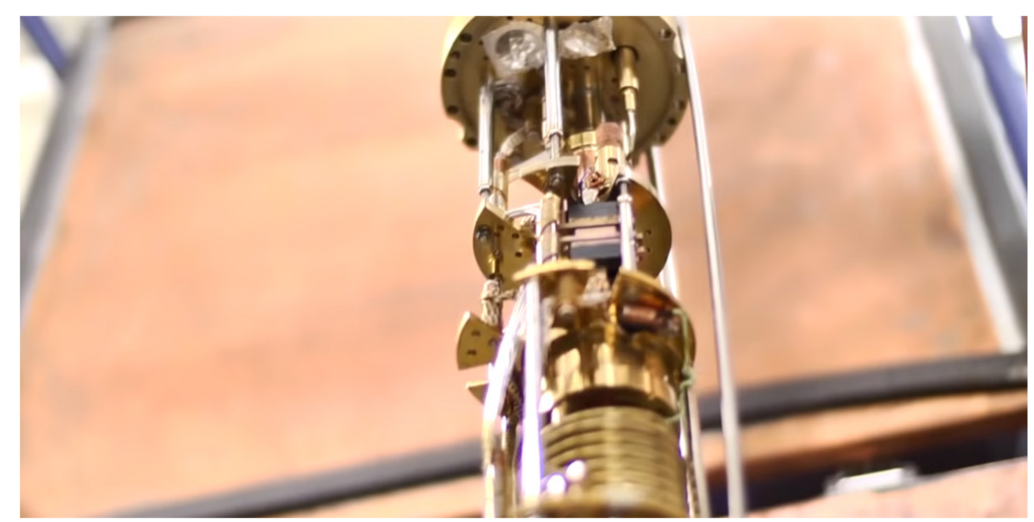


Image: (i48) Quantum Cooling to (Near) Absolute Zero

References: (i48) https://www.youtube.com/watch?v=7jT5rbE69ho&list=WL&index=61&t=11s Youtube 2veritasium , (i49) Marko Korosee Weather Photography

For larger structures, if the structure cannot be lowered, then it is plausible to build scaffolding, followed by the large magnetic units and support systems that can then be erected and powered to a low energy level. As the material is added, power can be increased to offset any sinkage. For tall buildings climbing cranes can be added to the exterior. For bridges, prefabricated sections should be constructed parallel to the water surface and then raised onto a lowered upper magnetic section.

Image: (i50) Electromagnet on its journey to Fermi National Accelerator Laboratory in Batavia, Ill

Transportation of large-scale prefabricated structures for laboratories is a big deal in the current age. These involve repaving roads, removing signage and lamp poles, planning routes around bridging, and significant escorts and road closures. The logistics of this can be seen in the move of this large electromagnet to Fermi National Accelerator Laboratory in Chicago. These large-scale movements take months to years to coordinate and require special trucks with uniquely designed suspension travailing at a snail's pace to their destination.

References: (i50) Photo/Daily Herald, Emmalee Luckas

References: (a)

II

Criticisms

Chapter: 17 Goal for the Future

Despite all these logistical and economic issues, they aren't impossible and have potential uses. Optimistically these kinds of grand projects open up even grander projects even farther in the future.

Throughout this thesis book, I provide several examples of potential projects consisting of several different scales regarding the time of future the project could be placed in, concerning size and function. I hope to provide a series of precedence that architects can look at in the future to help define their work. In a way, this project is also the first step to large-scale space infrastructure. What I mean by that is that most of these futurist planned large-scale space infrastructures involve technology, involving magnets that provide some structural stability. Examples would be the widely known space elevator, Orbital Rings, Launch Loops, and Atlas Towers. While these projects are technically possible, all require the electromagnetic systems described in this book to some degree. In a way, this book provides examples of a middle ground, so to speak, that a general Audiences exposed to some amount of Science fiction can more easily understand and accept it as a possibility.

While the initial historical precedents would help me focus some of my processes, I thought it also imperative to compare this with how large-scale electromagnetic systems would function and what kind of applications and benefits levitating buildings could provide. From the above research, I concocted several design charrettes to showcase the potential uses of the technology, using the properties of the magnets in unique ways to create them.

The first project that I showed was initially thought up from the historical precedence phase of my thinking. The project, a large-scale bridge across the Bearing Strait, solves several issues that a contemporary bridge would have in that climate using electromagnetic levitation systems previously described. Bypassing ice build-up at piers is the primary factor and allows ice flows to pass under and through the magnetic fields. This would also allow ocean currents to flow uninterrupted freely. Bridging as opposed to tunneling under the strait, which is what all current proposals propose, such a bridge built modularly and in prefabricated sections raised on occasion would be inevitable quicker. Such a system could also allow the foundation systems to be sunk on guilds to the seafloor, then piles to be driven in as access, and the previously mentioned airlock would allow for maintenance and the bridge to be able to be lowed and floated on sponsons in case of emergency.

The Second concept came to me when looking into the separation aspect that magnetic repulsion can provide. By using the repulsive properties of magnets to protect the structure from seismic activity and extremely delicate instruments while providing 360 degrees of movement, the observatory seemed like a prime candidate to superimpose the technology into. Locating the project in an area known for observatories such as California as it has extremely active faults, the location and typology seemed to perfect to pass up as a small scale project that is both practical and popular among the general public for visiting.

The third project again looks at separation and movement through the lens of security and vertical instead of rotational motion. Inspired by all the recent all, be it controversial city buildings in the middle east and Egypt. Egypt's massive governmental move from Ciro to their new administrative capital, I thought a re-imagining of the embassy for the US to be a perfect project to showcase this particular use for the technology, especially given the raids in past years on the embassies in the area. The goal of the design was to create a way to show the friendly nature of the US while still allowing separation of private embassy functions. The electromagnetic levitation systems allow for on-demand separation between public and private space. The embassy is designed so that the public can enter the space below and interact with a new public embassy program when in an elevated position. However, if a threat is detected, the structure can lock down, literally lowing blocking the entrance to the main initially levitating structure. The last project was intended to push magnetic technology to its limits. Using a scaled-up version of the electromagnetic systems in the book to create a vision of a mega tall skyscraper arcology set in New York's upper bay. The project's main focus uses the electromagnetic systems to replace in water concrete foundations instead barring the foundations under new Yorks Harbor in the bedrock. Additional magnetic supports on key structural floors also allow for the complete negation of wind sway at any elevation and in any direction; this works by regulating power to corresponding magnets, thus countering the incoming wind.

All these projects went through several levels of design to varying degrees of detail. Still, most are left purposely ambiguous as to material, interior circulation, and such things as they are but an example of what the technology is capable of.

Image: (i51) Space Elevator Illustration

References: (i51) Kenn Brown

References: (a)

II

Criticisms

Chapter: 18 The Skyscraper Argument

The main reason for this chapter is as follows. One of my main interests is skyscraper design as such. As one of my categories in the history portion of this book as well as one of the projects that showcase the anti-sway technology, I found it surprising that a large portion of the architectural community is against skyscrapers so much so that they are collectively in the belief that skyscrapers in the future will not continue to be built. This section exists to argue against that politically driven point.

Capitalism is arguably the foundation and backbone of the world's technological and economic achievements. To not have capitalism is not to have industry. It is not unreasonable to say that the goal of most people is to live comfortably; how most people go about doing this or at least try and go about doing this is making money. They do this in a broad general sense by making or selling goods and services.

At a certain point, however, it becomes impractical or even impossible to produce or even think of complex goods or services as the human brain is only capable of so much. Thusly the next logical step is to create a place where multiple people can work or think about a given thing or idea; thus, groups, we'll just call them companies for simplicities sake, are formed. These groups, which either make (Industrial) or think of things to make (Corporate), need people to work with them; thusly, they move to cities where people are. Thus as we saw in the history portion of the paper, skyscrapers were invented to get more people closer together. This inherently is not a bad thing.

The main argument that I hear all the time is the corruption of these companies and how they treat their employees. And yes, this is a problem to some extent, but this has nothing to do with whether any company should exist or not; there are ways to solve this without just sayings its bad and needs to go away. In the modern world, all technology doesn't exist without these companies.

Another argument that is said a lot is the efficiency of the skyscraper, and yes, even the newest towers are not as efficient in terms of both electrical and construction co2 emissions. However, most of these statistics stem and overlap with data from older structures muddying the data set to make skyscrapers look bad because of the poor building practices of yesteryear.

This argument also extends to the efficiency of the height of a structure. After a certain height, it is just inefficient to build. This is also misleading as the data that first suggested this uses outdated building technique and not the new technique and systems we have developed over the last few decades.

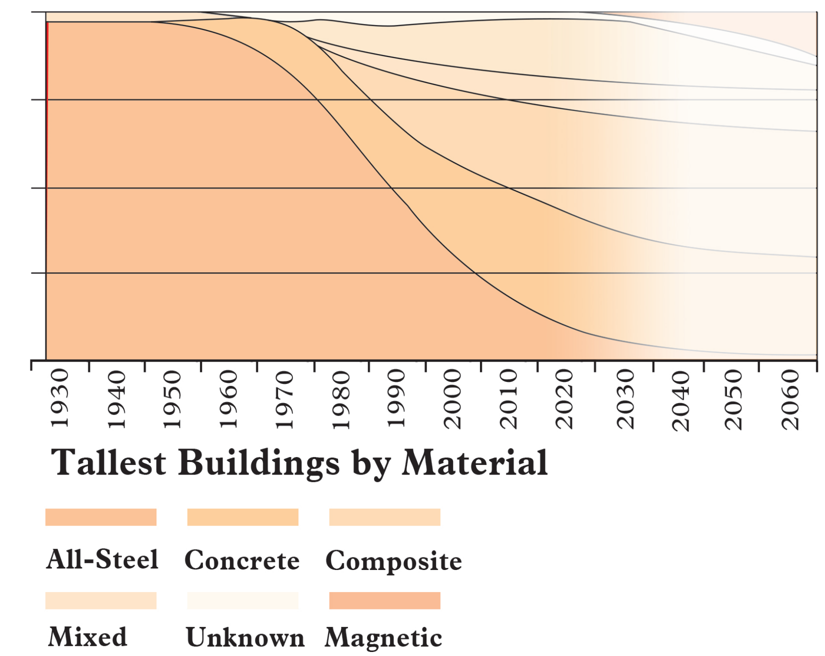
Even if it turns out that modern building technique still make these mega tall structures inefficient from a co2 emissions and electricity standpoint, the global power crisis, as discussed early in the book, should put an end to at least part of that as well as the co2 emissions from transporting goods to the site during construction.

This, along with the steady rise of population, will surely still call for the construction of skyscrapers in the future, especially in the distant future. While we will always keep some aspect of the natural landscape even in the distant future if the current trend of low-rise single-family suburbia continues

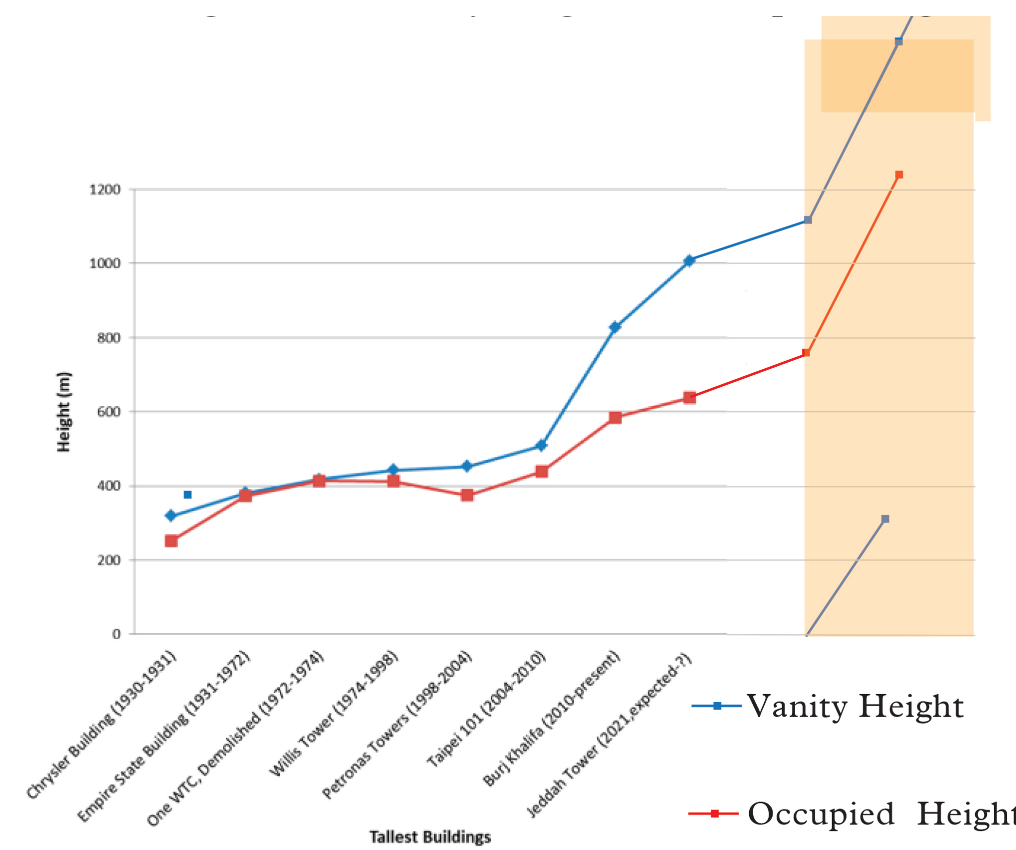
Most of the forests and land will be cleared completely within the next 200 years. So, in reality, it is better to build these incredibly dense structures than destroy the natural landscape to create an equivalent amount of single-family homes that are unnecessarily large.

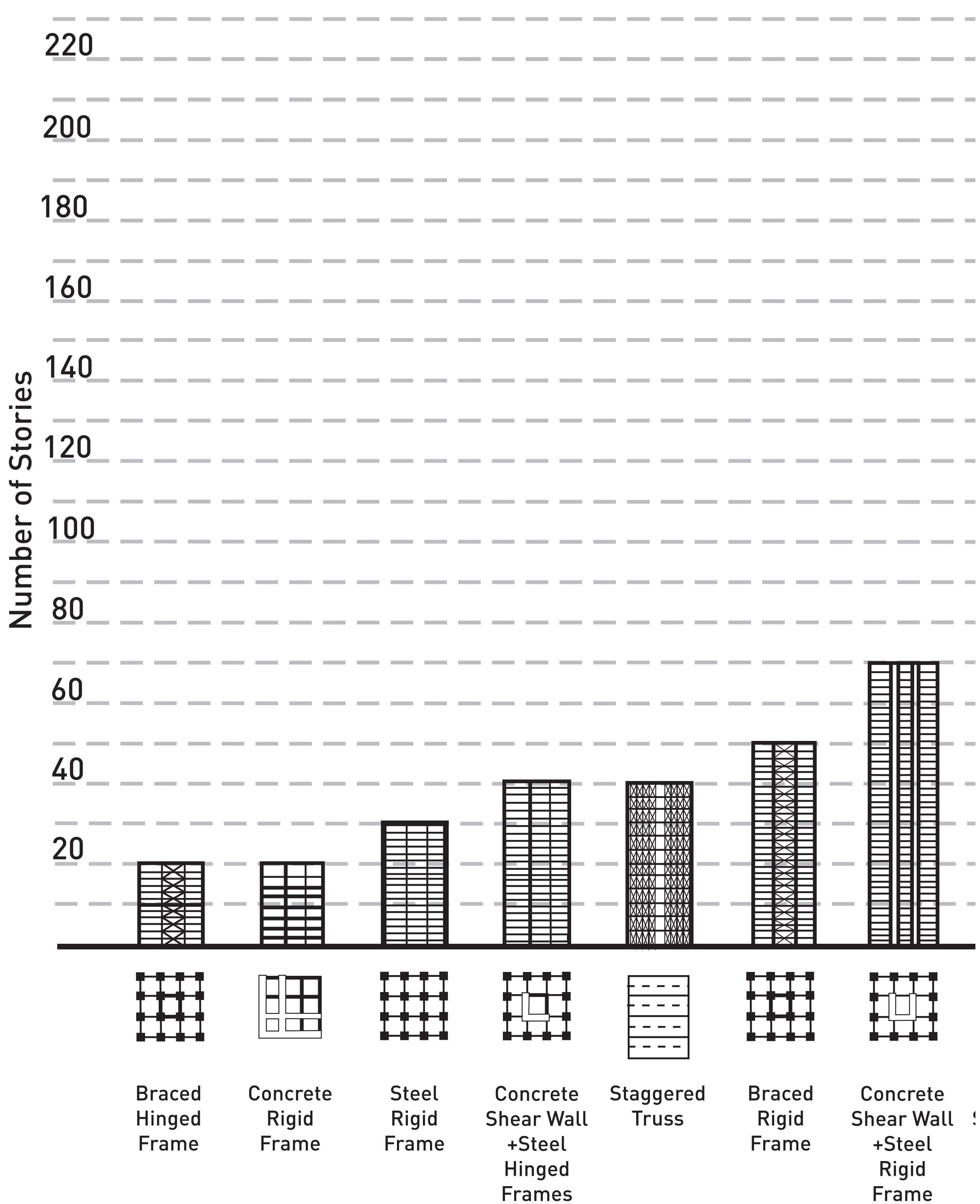
Another common argument is that they are ugly structures with no sense of place. If you think skyscrapers are ugly, that is an opinion, not a fact; as for them not having a sense of place, that is true to some extent but is more of the architect's fault or the client's fault than that of the existence of the skyscraper as a form.

The excessive mega tall skyscrapers act as a monument of sorts to whatever entity funded them, and this is not a bad thing

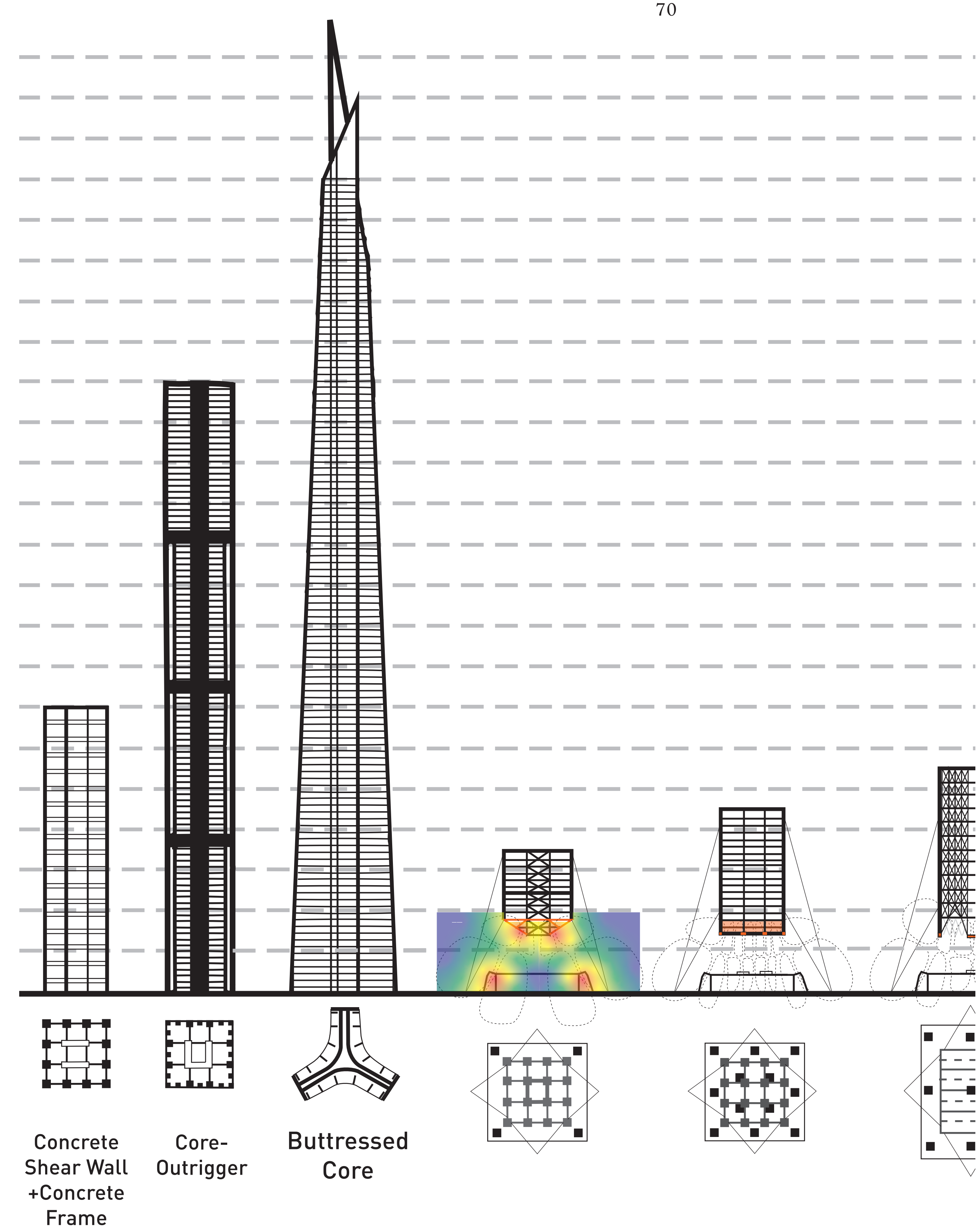


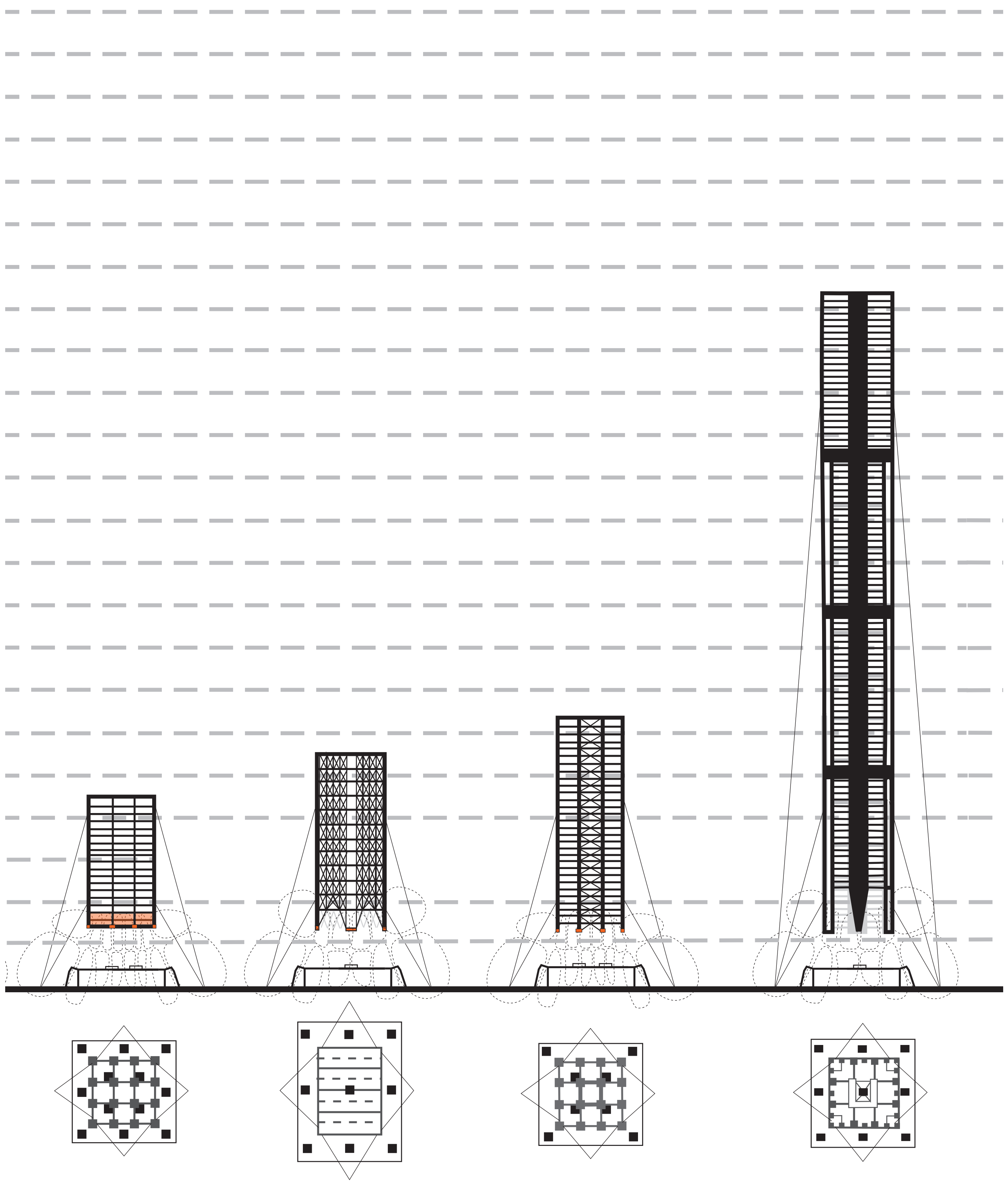
Information from The Council on Tall Buildings and Urban Habitat

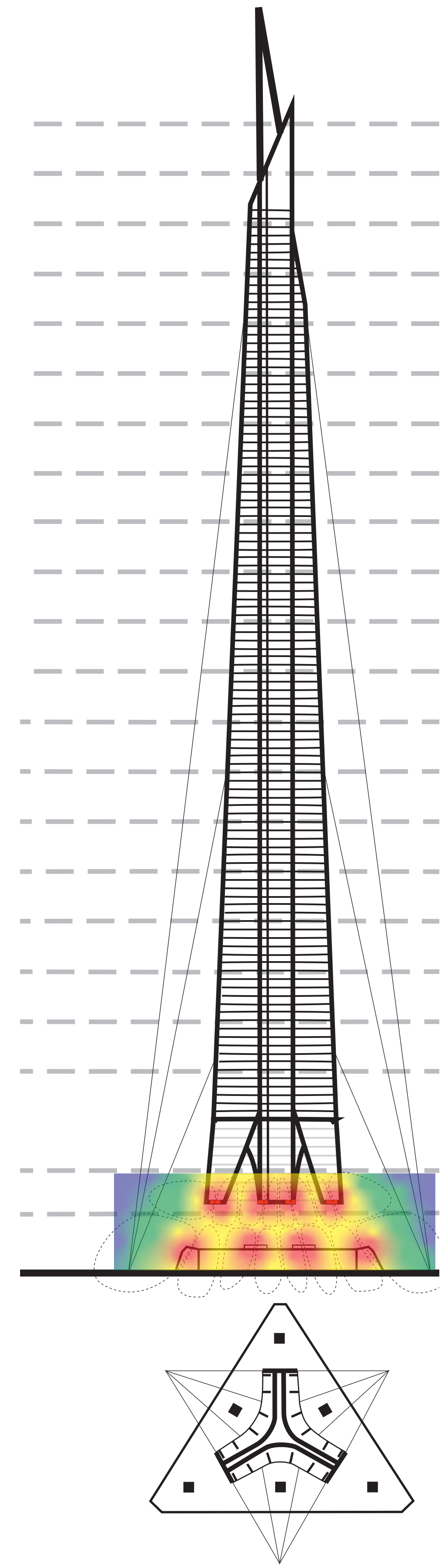


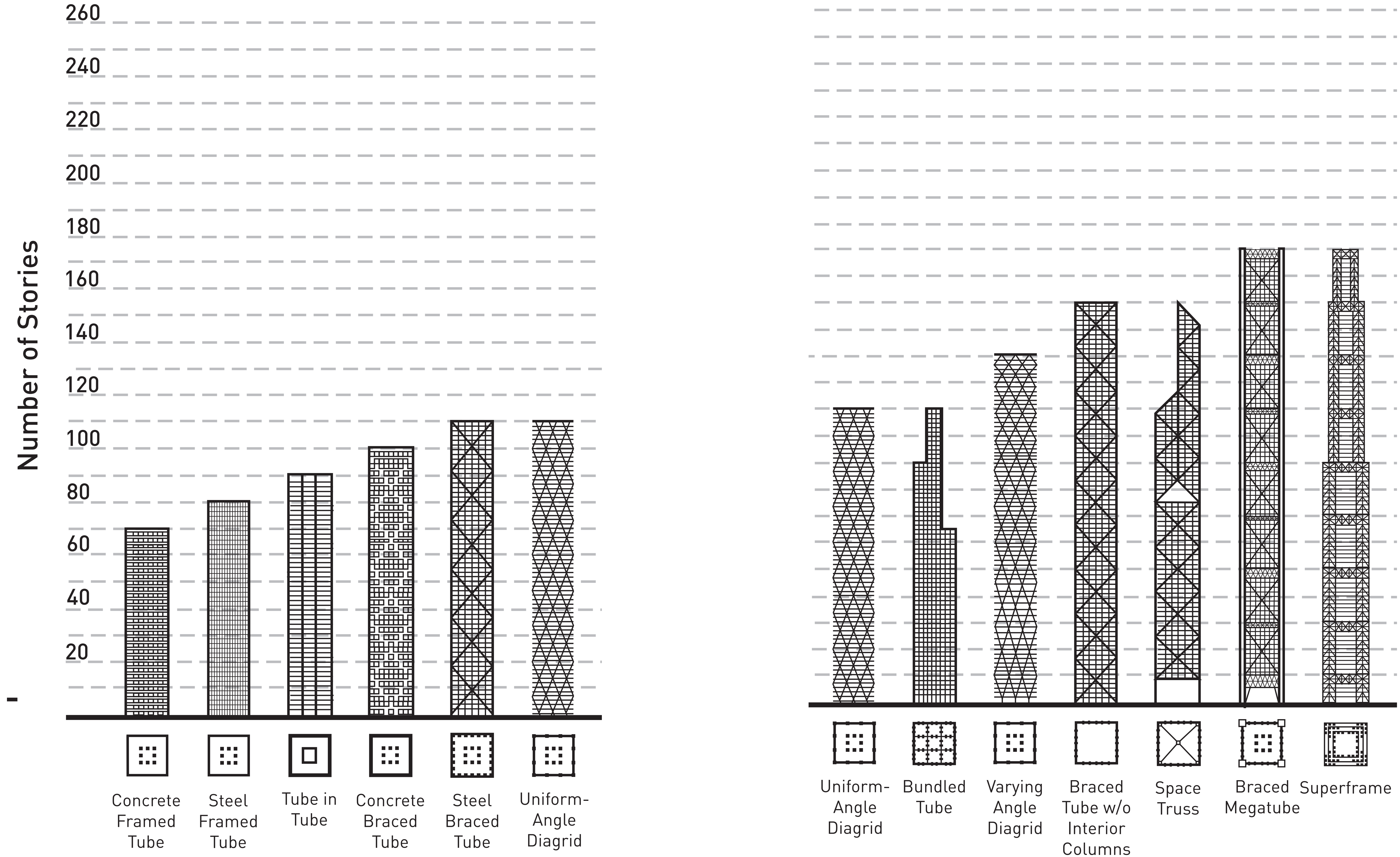


(a) Interior Structures

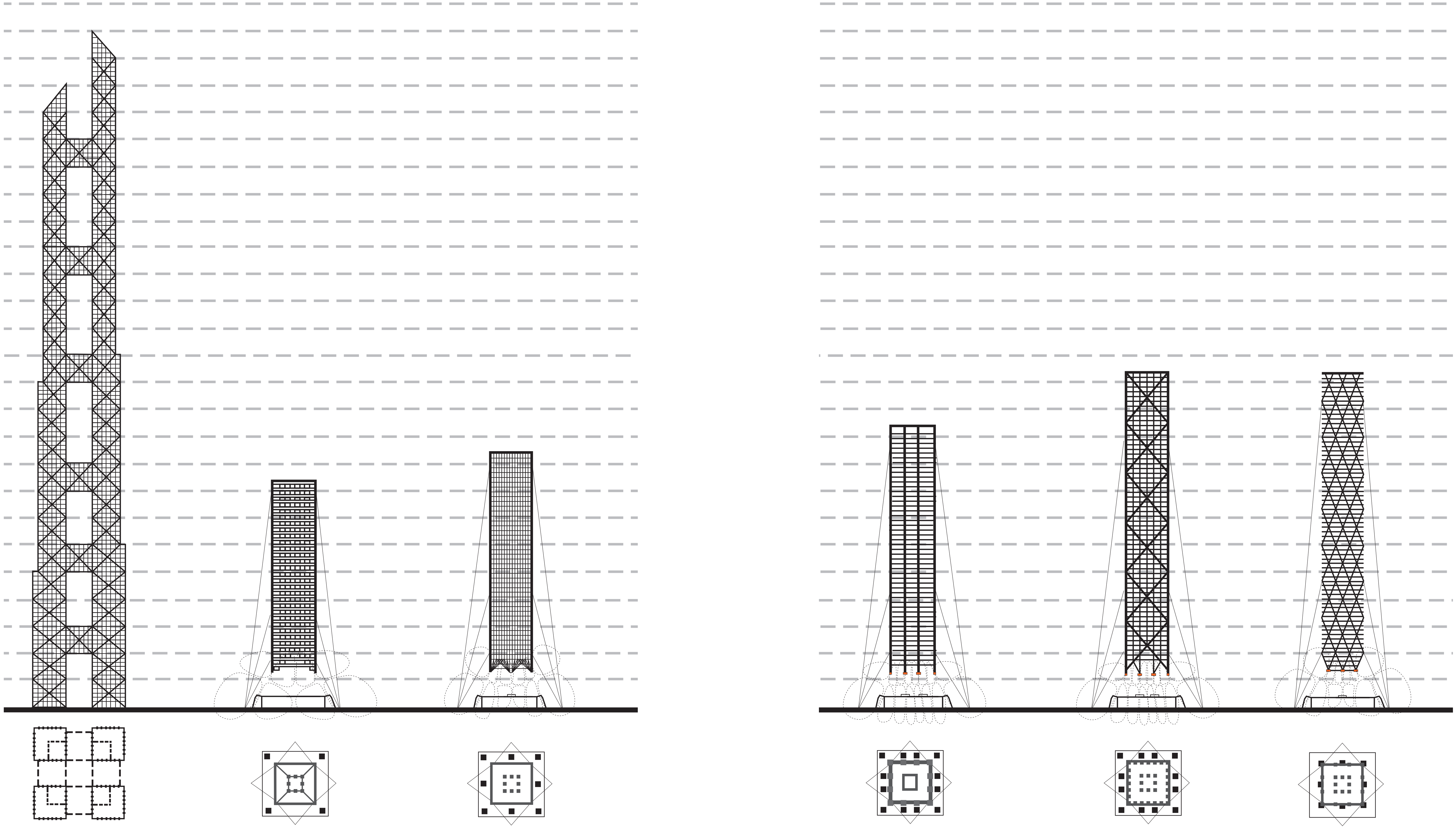




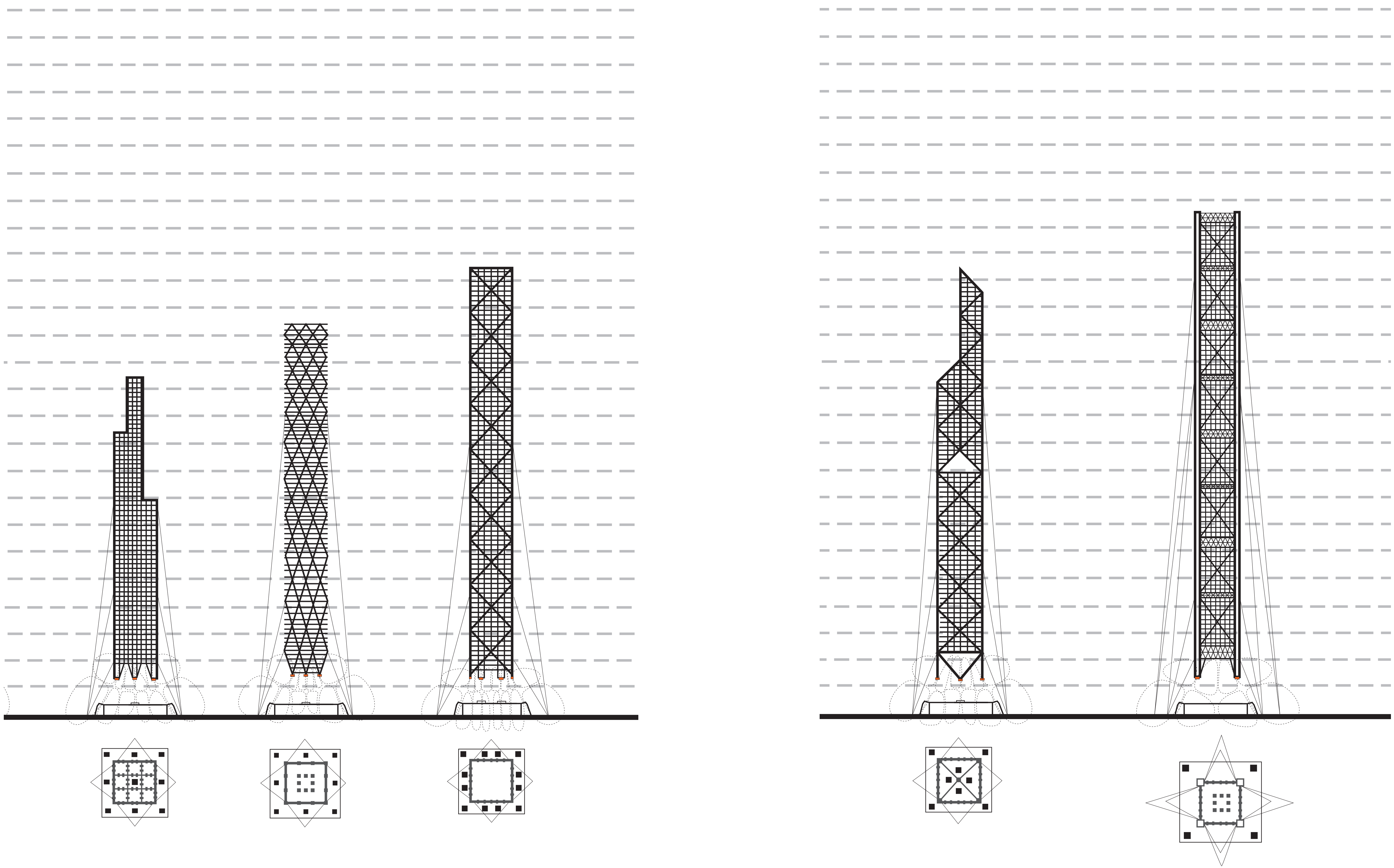




(b) Exterior Structures



Superframed
Conjoined Towers



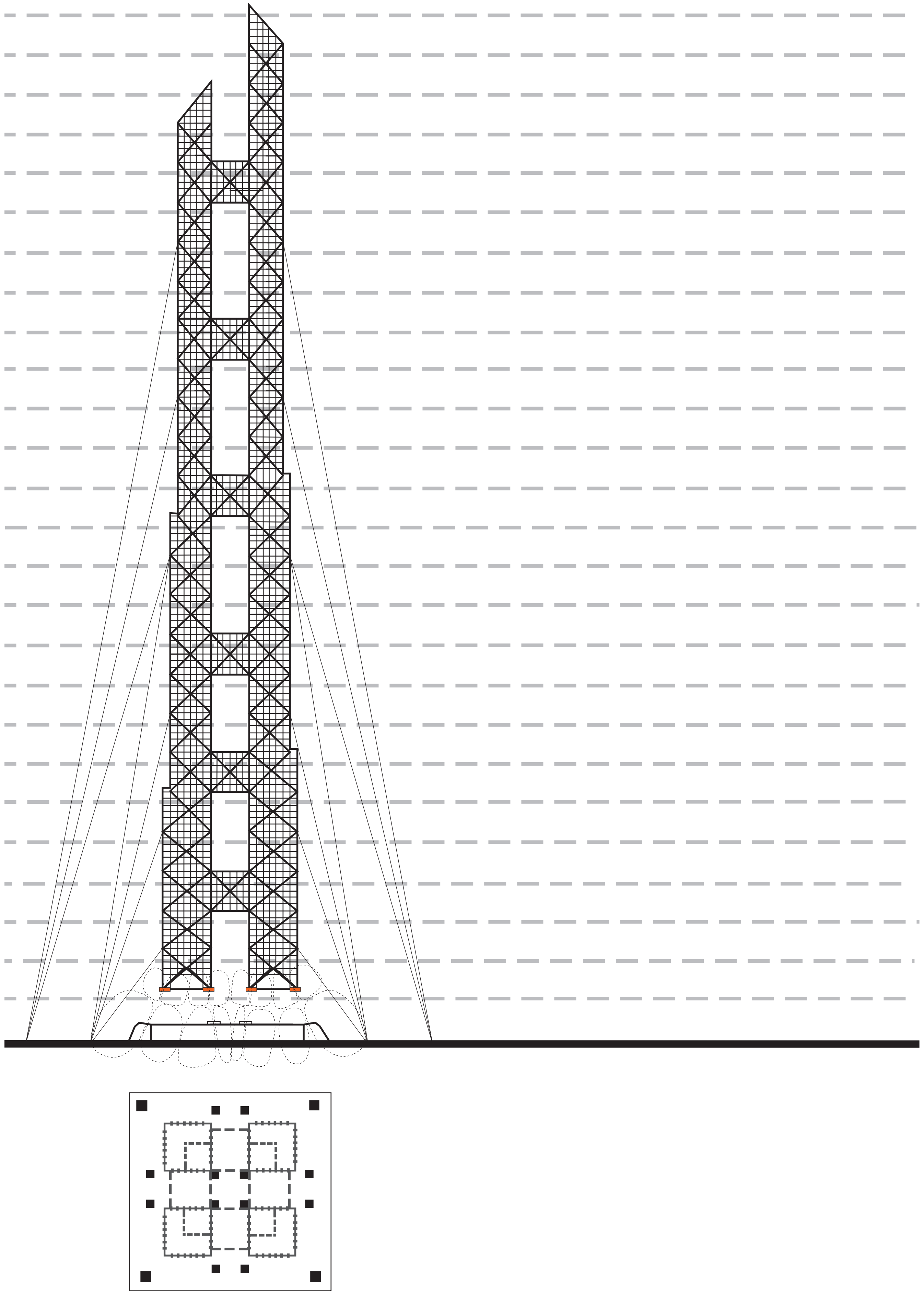


Image: (i57) Super framed Conjoined Sky Mile Tower Japan

Image: (i58) Super framed Conjoined Tower in Chicago

References: (i57) https://www.urukia.com/sky-mile-tower/ , (i58) CTBUH Journal, 2015 Ussue II

II

Designing with magnets in Structures

Chapter: 19 Designing with Magnets

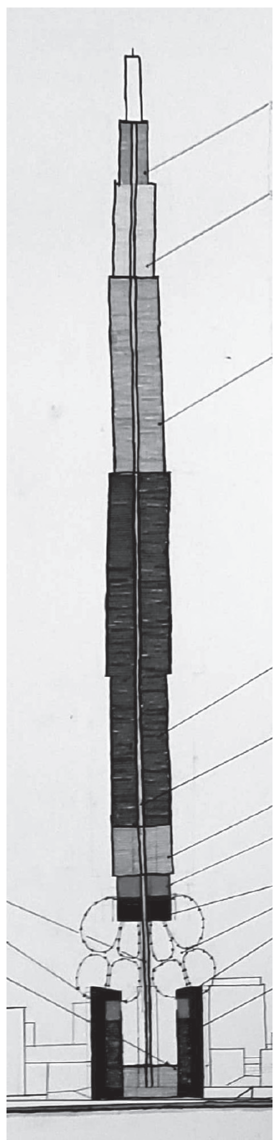


Figure: (f14)

Sizing the space and magnetic field Drop Off is tricky; however, once done, it can offer a picture of how the entrance of a levitating structure can be designed.

The uninhabitable zone around the base of the upper levitating structure makes designed entry into any structure levitating a challenge. However, in this, I have several proposed methods of entry.

Sinking the foundation below grade so that the levitating structure's entrance is at grade, allowing for a bridge to cross over to the entrance over the inhabitable field zone. As seen in the figure below, the entrance can be placed at grade if the field is sunk.

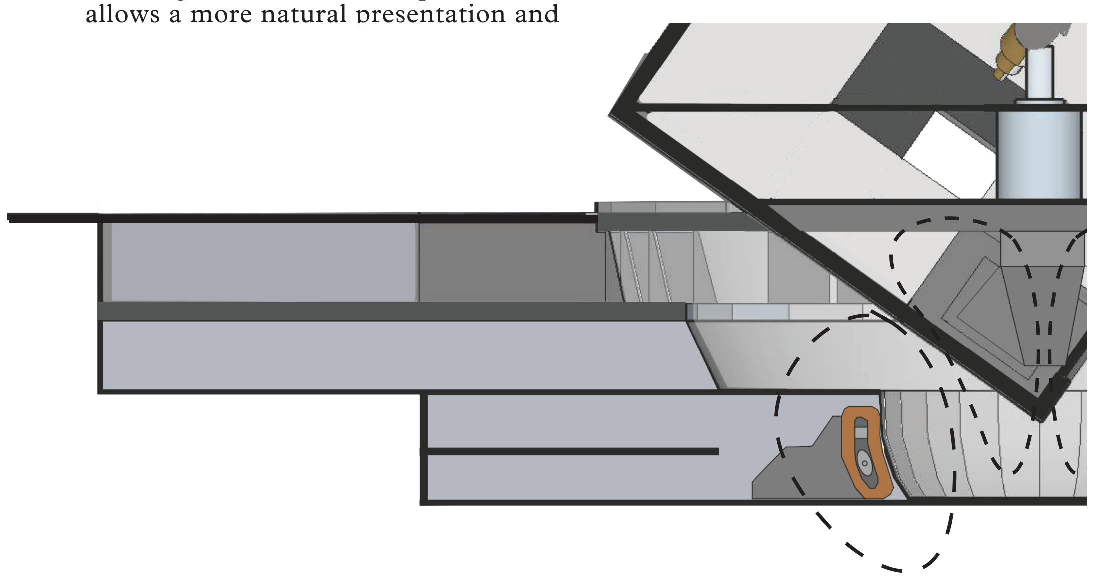
Another way is to push circulation up and have the core of the building become uninhabitable so that the main levitating structure can still be used as a centerpiece.

Alternatively, placing levitating structures at the bottom of a hill and having access be at the top of the hill allows a more natural presentation and entrance the structure.

While uncertain if the following method would work, it could be tested that a protected elevator or even hung cable car could penetrate the uninhabitable zone by using a Faraday cage-like structure on the exterior of the cab or even in some sort of protected elevator core as seen in the sketch of figure *(f14)* .

Bearing the electromagnetic systems underground as purely functional could also be done as well as covering them up with redirecting material.

Anyway, one could look at it a structure using an electromagnetic system to levitate face a severe challenge of circulation in and out of the design.



II

Designing with Magnets in Structures

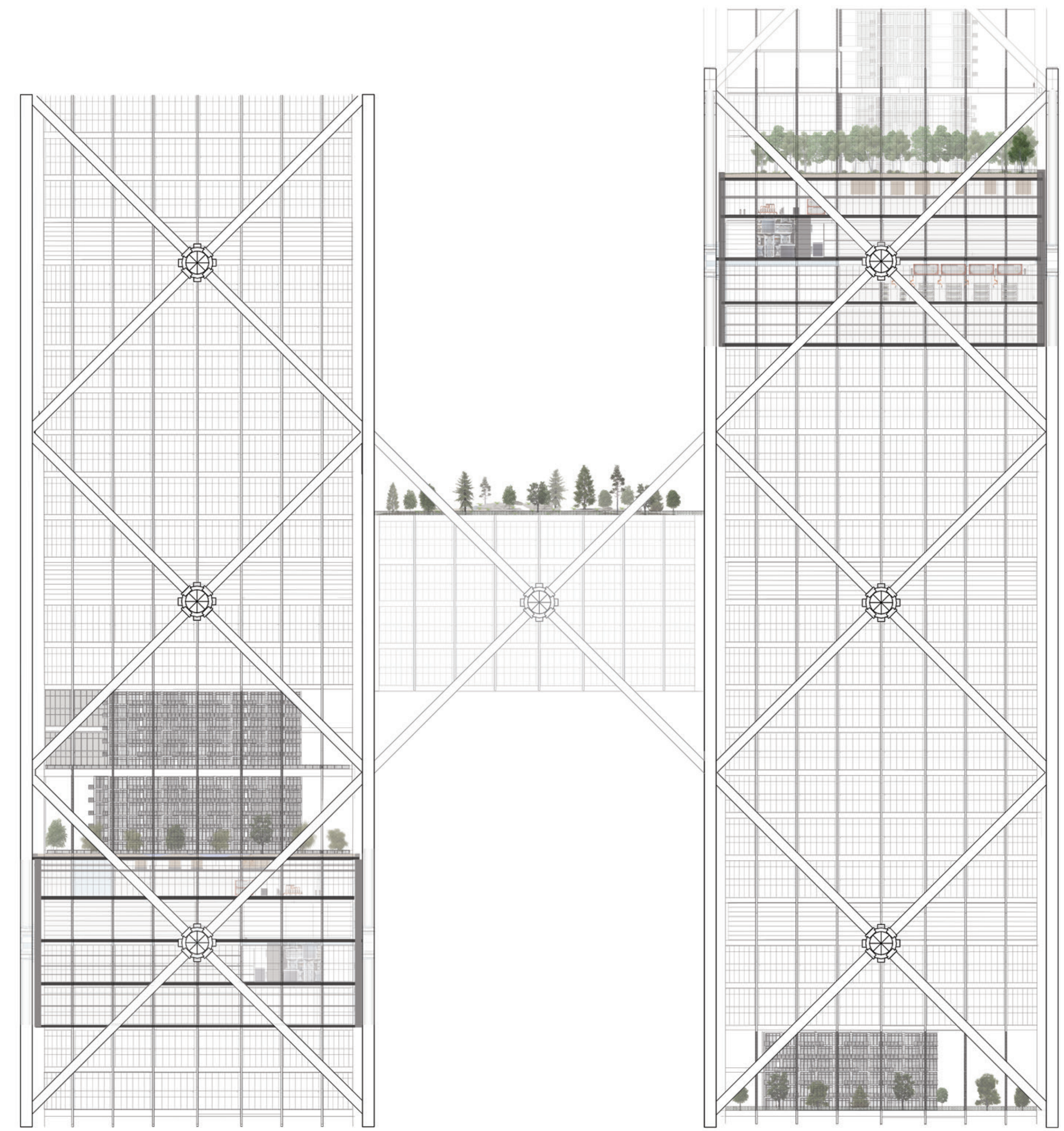
Chapter: 20 Magnetic Considerations

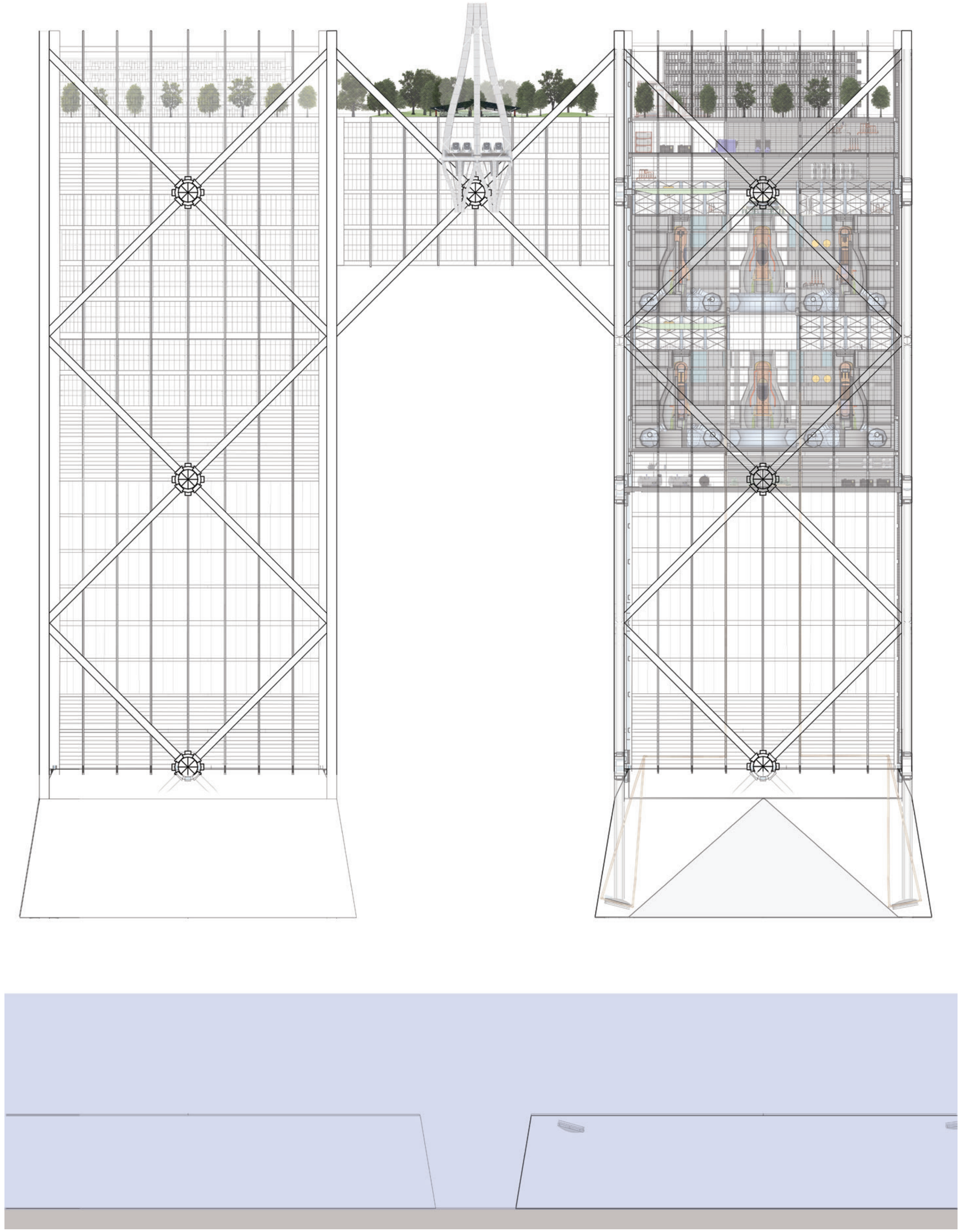
Other than the main system that we discussed before that involves the upper and lower portion of the electromagnetic levitation engines themselves, the cryogenic cooling systems which involve pumps and tanks of liquid gases like hydrogen and helium, the various on-site power generation facilities as well as the backup generators and support computers, other systems may be worthwhile to include.

On major consideration is wiring power and other utilities to the structure; this would have to be done through, underneath, or up any entrance that has been constructed, especially for water and sewage. However, power could be sent through wireless means to the structure. Like the wireless power receiver in the back of a modern smartphone, the bottom of the building itself can passively feed off the electromagnetic field current and receive power without any additional equipment on the foundation side.

Conditioning for the space can be done by routing water or air depending on the structure's scale or the client's desire to use the cryogenic systems to cool. The excess heat from the electromagnetic systems to heat is recommended. Typical mechanical floors with typical equipment would be more suitable for larger structures such as skyscrapers.

For the larger skyscraper structures, the computer systems would be vastly more complex as the magnetic systems work not only to work against the vertical load but the horizontal as well. The computers would have to calculate power reduction to specific magnets and allow the building to fall into the wind negating the sway through sensory data. These sensory and computer equipment and mechanical equipment would necessitate large mechanical floors. For even larger mega tall structures that hold their power stations, it might be necessary to have water processing facilities. Using and converting gray water and even cleaning or storing water at certain levels lower in the structure. All this might culminate in multi-leveled mechanical floors that span two or three floors.





II

Designing with Magnets Small Scale

Chapter: 21 The Near and Far Futures

While the systems talked about in this book aren't economically possible to create in the modern-day, it is possible to do some theoretically. My prediction and hope are that the research and development of the magnetic systems touched on in this book will start to become more common in around 50 years. This, however, is just the beginning, and we will most likely only see the technology used as a temporary wonder at first, most likely in some exposition as a piece of art rather than a functioning habitable building. Then over the next hundred years, more and more structures will most likely use the technology as the magnetic systems become more normalized and the public better understands it. The electromagnetic levitation systems will most likely still be used in smaller buildings. They won't be used in larger ones until the public becomes comfortable with the safety standers of the smaller structures.

Once larger structures start to use the intensive power systems, this thesis aims to completely normalize and build trust in the technology so that it may be used in the expatriation of humanity off of the planet.

Mega-projects in space can be on a scale unimaginable to the average person today and are only seen in the likes of science fiction like Star Wars or Star Trek.

The move to space is inevitable, the earth will always be valued as the home world, but many in the distant future will be born off of the planet, perhaps right above it.

With the vast amounts of untapped resources of the asteroids that have the capacity to a user in an era of post-scarcity and allow construction material prices to basically be almost nothing, practical anyone could potentially build anything. While that future is far off, it is imperative to the human race that we strive to do that by leaving the planet. Due to the earth's gravity, conventional rocketry makes it extremely expensive to send objects into space. While Elon Musk has dropped the launch cost considerable with his reusable and efficient rock designs, it is still to expensive to get the materials we need into space for the infrastructure we need to, capture additional materials from asteroids, to process said materials into usable compounds, and to used the processed materials to construct more infrastructure to reduce the launch coast even farther. It is for this reason that massive concepts like the space elevator exists.

Mentioned briefly before, mega structures like the space elevator, launch loops, atlas tower, and orbital ring are vital in dropping the launch cost to typical postage rates, which would facilitate the development of infrastructure for the upper atmosphere and inner orbit for human habitats.

Researching the popular idea of space elevators right away, I have to admit they are actually impossible to construct after much research. The tensile forces inside a structure that tall and had that much centrifugal force would be so massive. So massive, in fact, that it exceeds the strength of any and all known materials. This means that they are impossible unless new stronger materials are miraculously discovered.

The launch loop, atlas tower, orbital ring are other little-known mega structures. These would provide a more realistic idea of how the launch coast could be reduced.

Image: (i52) Analemma Tower Space Tower design

References: (i52) https://cloudsao.com/ANALEMMA-TOWER

Image: (i53) Orbatal Ring

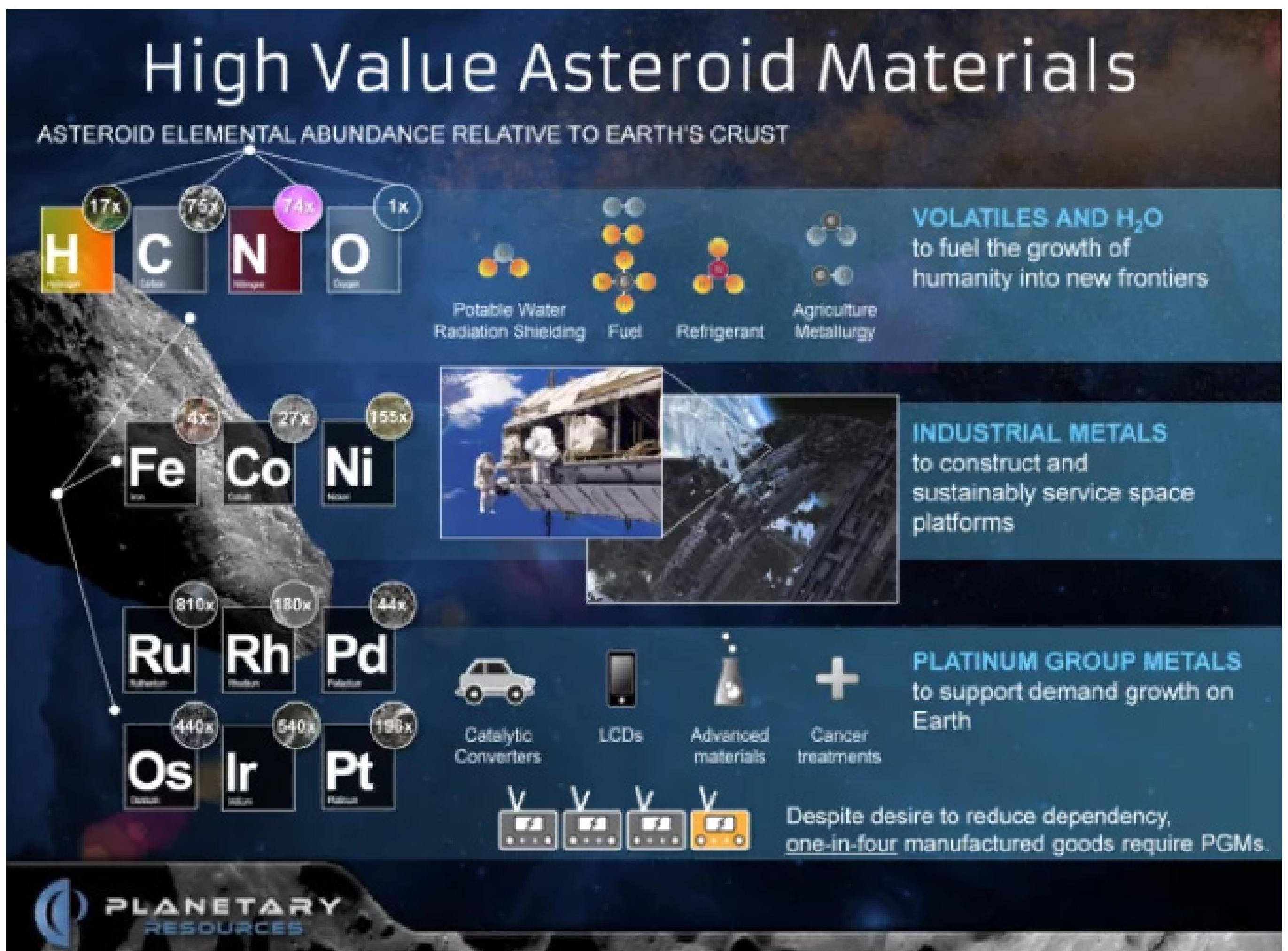


Figure: (f12) High Value Asteroid Materials

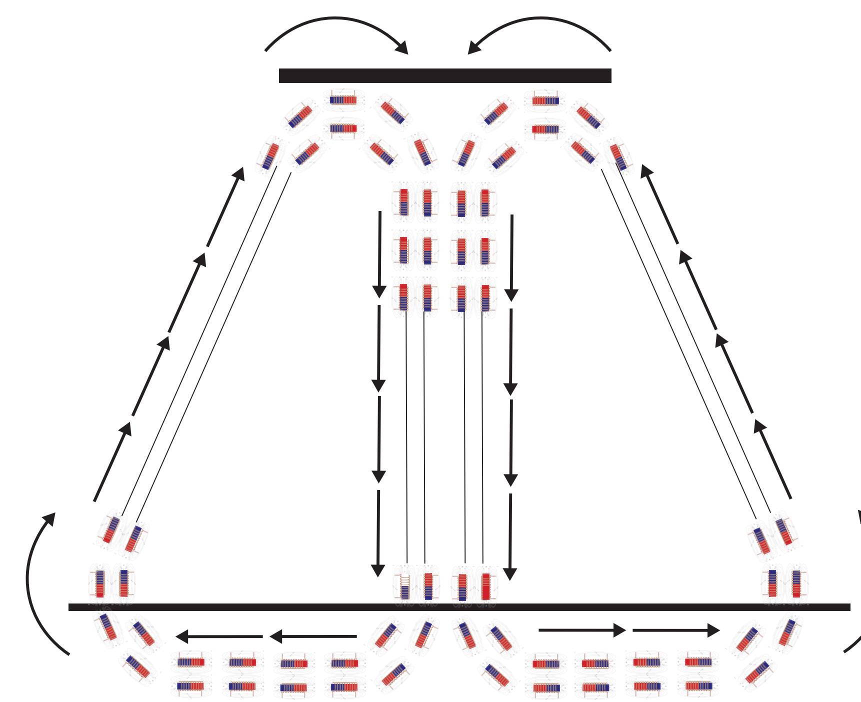
References: (i53) http://www.bisbos.com/space_earthring.html , (f12) Planetary Resources

Launch loops, however, are the most unrealistic of the bunch. Requiring a large and long area to occupy.

This large area would be occupied by a massive vacuum tube lined with electromagnets to accelerate a unique craft explicitly built to break out of the earth's gravity. The tube would be caped with an airlock that would open and close as the space vehicle approached it. The tube itself would be inclined and would launch the vehicle approximately at a 45-degree angle instead of a typical 90-degree angle launch of ordinary spacecraft. This is obviously impractical, and in all seriousness, will not be built even though it is seriously thought about in the scientific community.

The Atlas Tower is the quintessential mega skyscraper and can be built using magnetic levitation technology. The difference it holds from a regular skyscraper is that most of its floors are uninhabitable, only serving to hold up the upper portions of the structure. The idea behind it is to move the launch point to higher in the atmosphere, which would require less distance to be traveled and thusly less fuel to be used.
While better than launch loops, the process still uses chemical fuel to launch and requires a vertical launch system to be balanced on top of an extremely tall tower.

Orbital rings are the best option; however, the largest scale one as well. The ring part of the name comes from the super massive particle accelerator that encompasses the entire planet. The 7,917.5 mile diameter ring consists of multiple particle accelerators constantly providing their own rigidity. The best way to describe how they work is like a garden hose; when the hose is turned on, it becomes ridged, and an arch is formed. It is in this way that the structure holds itself up. On top of this, various bits of infrastructure can be built and cables that can go from any point on the surface to any point within reason on the ring. Additionally, the ring does not have to be built at the equator like the space elevator has to be; it can be made smaller and at an angle to mid max that amount of potential cities any off cables could be attached to allowing more people and goods to access space. Another type of mega structure that uses electromagnetic at its core is the space fountain; this can be scaled down for building size. However, it is extraordinarily complex and would most likely be considered unsafe by the general public, as you will soon see in my explanation. The space fountain is best explained by another analogy, using the garden hose, except instead of a self-completing loop, the end is cut off, and the water is allowed to jet out of the nozzle at a target held in the air; this will allow the object receiving the jet of water to be pushed. In this way, space fountains work by using magnets to accelerate small magnetic projectiles and slamming them into a target, then collecting the pellets and recycling them. This is the equivalent of the stereotypical cowboy throwing a coin into the air and shooting it multiple times to keep the coin aloft. In this case, the gun is a rail gun, the bullets are most likely iron shavings, and the coin is a building. Additionally, the path the projectiles travel would have to be at least a partial vacuum, so an enclosed tubular structure would have to space from the ground to the target.



References: (a)

III

Design Cherrettes

Chapter: 22 Introduction to designs

The following chapters are the culmination of my research over the past year and represent through design four different scales and four different ways electromagnetic levitation can be used in architecture in the practical sense. The following designs worked on for approximately two weeks each are not full fledge designs; when examined closely, they have their flaws and are meant to be concepts depicting the use of the technology, being more akin to massings and spacial planning.

The order in which these might be built was touched on in previous chapters after exploring the electromagnetic technology further and adding to the historical precedence that was touched on initially. Bridges will be the first design presented as they generally were the first to use a new structural technique form a historical standpoint.

Next, however, I wanted something more small-scale with slight public interaction so that the Observatory project would take the second design slot.

The third will be the Embassy design which interacts with the public slightly more and in a more urban-centric build.

Finally is the mega tall arcology project, which heavily focuses on systems in the structure and at the base.

All these projects will have additional sketches and renderings in Appendix C. The mega tall skyscraper arcology project was a significant focus and will have several iterations at the back of Appendix C.

References: (a)

III

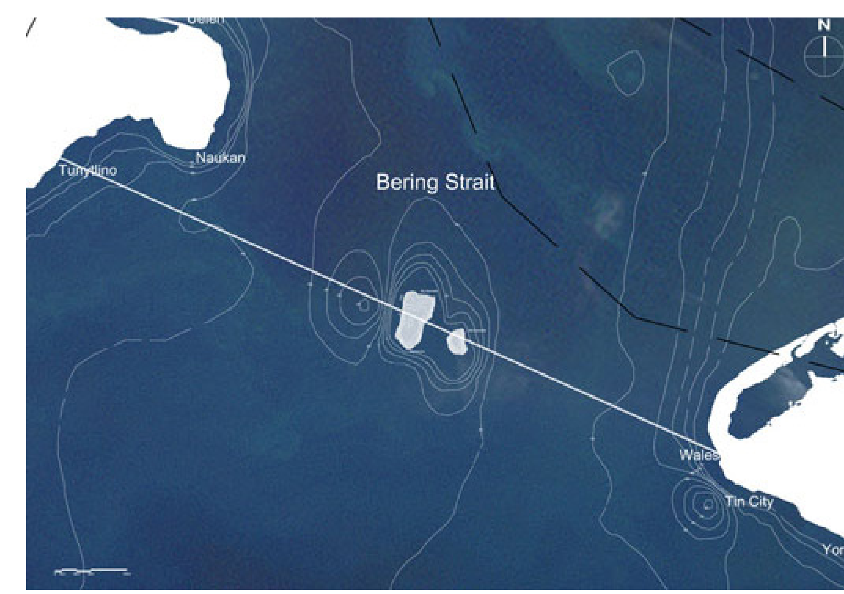
Design Cherretes

Chapter: 23 The Bearing Strait Bridge

Proposals for a bridge and connection across the strait go back as far as the 18th century, with proposals from mayors of cities to the Tsars of Russia. The idea to connect the two continents by tunnel is proposed by China and supported by over six countries, including China, Russia, Canada, and Korea. Japan, and the US. While the proposed high-speed rail connection that would supposedly boost tourism in all six countries, the pandemic in 2019 and the Russian aggression in 2022 put an end to any ongoing discussions about how this would be accomplished.

However, the idea still stands to be brought up in the future. Flaming the bridge on magnetic fields could potentially solve many of the past problems engineers thought about when proposing bridge designs in the past. Potentially also faster than tunneling, and if power and the electromagnetic technology are cheap enough, it could cost less overall.

A levitating Bridge would have several significant advantages in the Bering Strait's arctic environment. Power stations would have to be located at either end of the Strait on the mainland, providing a constant feed of power. Depending on how or if ice forms on the seafloor, tidal generators could also be used to supplement power generation.



With the longest bridge span in the world currently being over 6,500,' it isn't impossible to think that that number could slightly expand. Keeping it conservative between each magnetic pier, a typical span of 8,000' for this future bridge proposal. This gives us a total of 16 magnetic piers.

The bridge itself would span 25 miles from Alaska to Little Diomede Ilse, span the small distance between little and

References: (a)

Image: (i54) Little Diomede Island in the Bering Strait

Big Diomede with a regular bridge and entering Russia Then Span the remaining 25 miles to the Russian Mainland in the Provence of Chukotka. For both the Russian and the US side Rail connections and road connections would have to be built. In the Proposal in the early 2000s China, Japan, and Korea wanted connections to stretch south from Russia into their countries to serve them as well. The road would likely be two lane as well as a double track serving long distant Freight and passenger.

The levitating piers would solve two major issues that plagued the previous bridge designs.

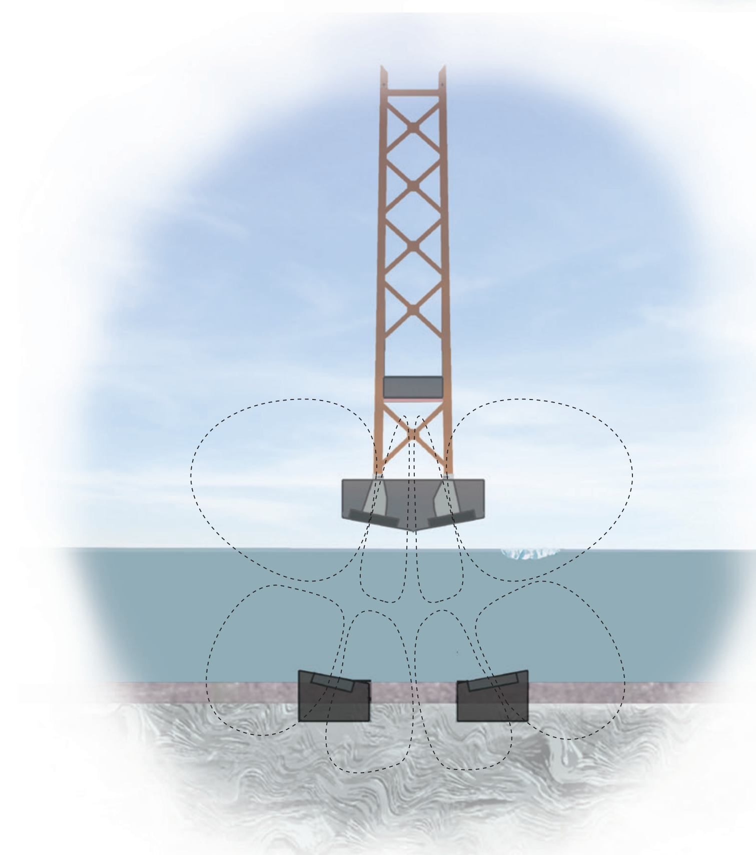
With the levitating piers sea Ice build up on the piers would be completely negated as the pries wouldn't extend into the water. In fact ice flows and currents could pass uninterrupted beneath as well lettings earths natural processes continue without hindrances.

Such a systems would also allow for the regulation of wind on the support towers.

However, the use of magnets in this environment isn't without risk of danger to the environment. Some sea life may be affected by the electromagnetic fields produced; whales, in particular, are known to be able to sense fields that guide them on their migratory journeys. To solve this large netting or some sort of active sonar-like signaling device might have to be installed around the piers to keep whales or other sea life at a safe distance from magnetic fields away.

When built in a modular off-site fashion, pieces of the Lower magnetic sections could be sunk and fastened to the bedrock at the seafloor. Then Construction on the main towers and bridge could take place in two different ways, on pontoons that float in the water until the system could be turned on and tethered temporarily back to the seafloor, or the towers could be pre-assembled off-site and shipped to the site and raised like a barn then attached to the magnetic levitating base. Either way, construction in this way would be considerably quicker than the current proposals' tunneling plans.

References: (i54)   Gregory Smith Flickr



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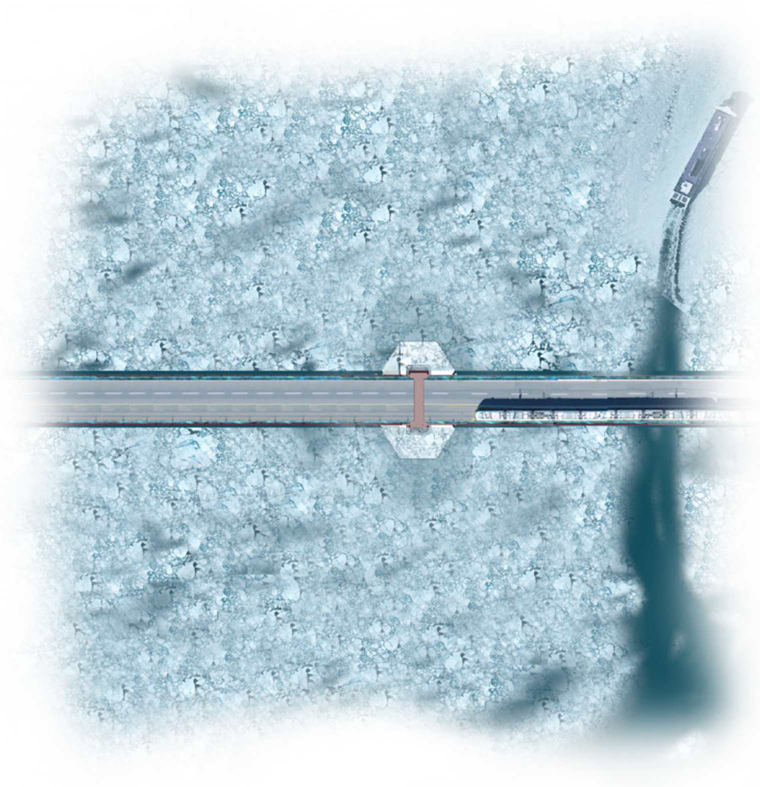

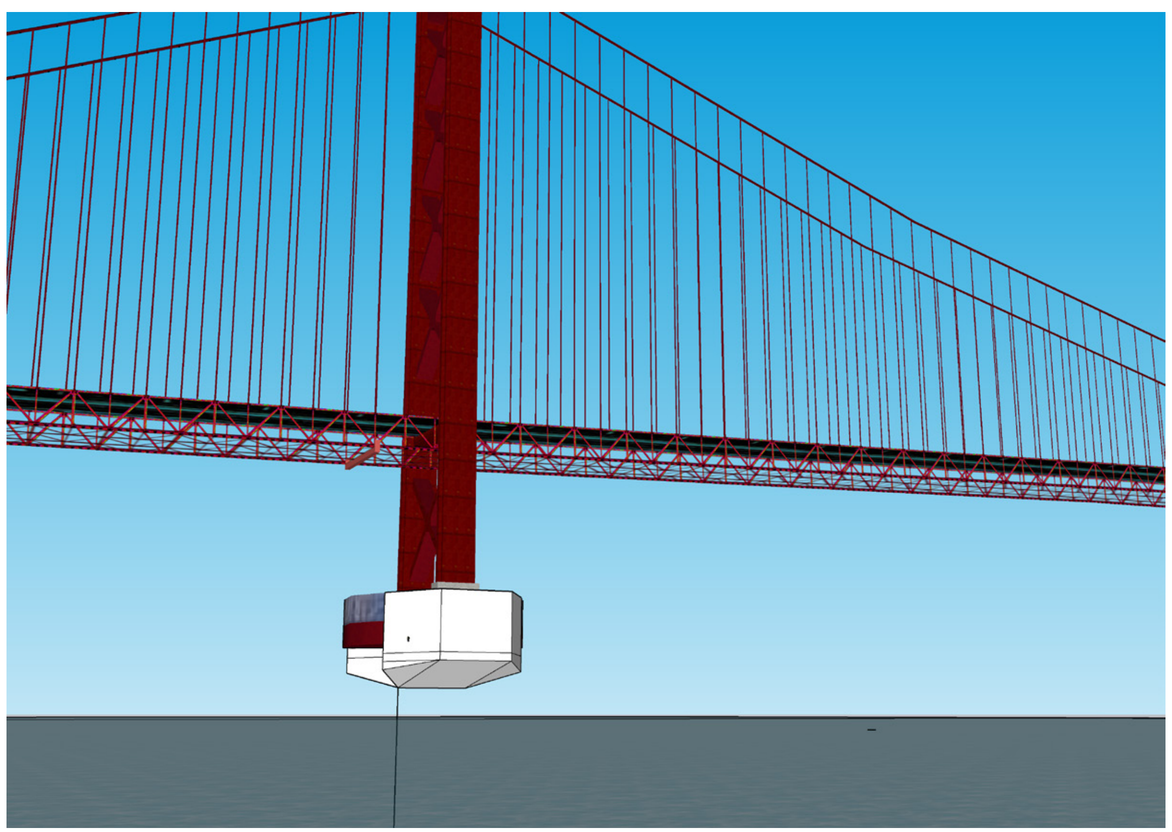

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III

Design Cherrettes

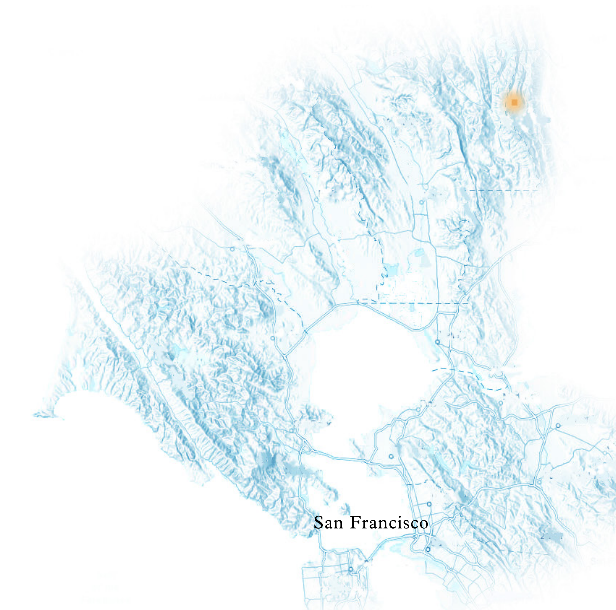
Chapter: 24 Observatory in Active Seismic Zone

For inspiration for a small-scale project, I looked to not the precedence of the past but what the electromagnetic technology could provide both physically and from a project standpoint. The ability to levitate off the ground meant complete seismic isolation. Looking at the magnetic levitation trains that Japan and China are using for inspiration, the idea that the structure could move was also incorporated.

The observatory seemed the perfect match. Not only does the electromagnetic levitation protect the structure and delicate lens and mirrors of the telescopes, but the electromagnets would allow the structure to rotate with extreme precision.

With precedent like the Griffith Observatory in California X, California seemed like the best choice for the backdrop of the Charrette. Locating the site in the Blue mountains East Northeast of Nappa Vally, The central structure would surely stand out if it were to levitate and become a centerpiece for the project.

Instead of using the typical dome-shaped structure, which is usually designed to allow the roof structure and the telescope to move, the entire structure would spin on its axis, with the only motion of the telescope to be vertical and allowing the building housing the telescope to be any shape.



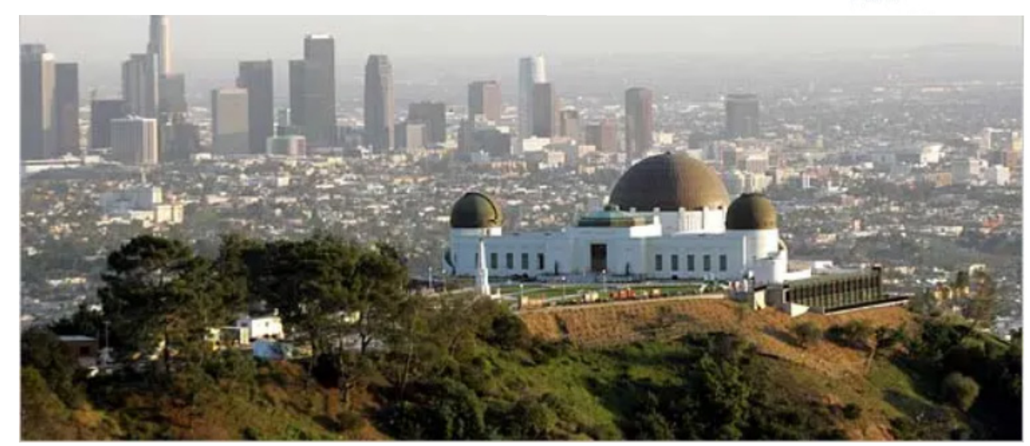


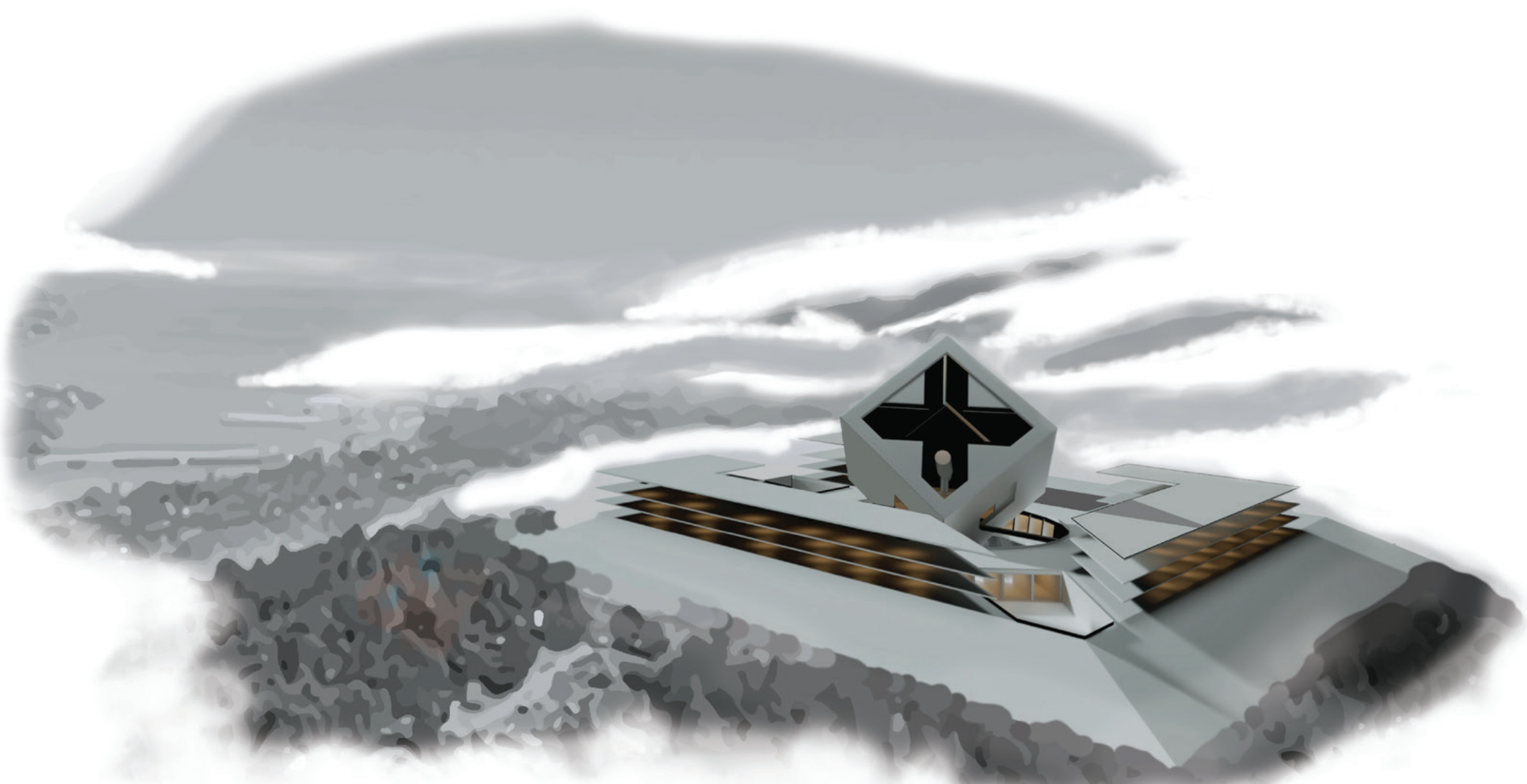
Image: (i55) The Griffith Observatory Los Angeles

References: (i55) J. Emilio Flores for The New York Times

I chose a cube as, in a way, it is the opposite of that of a typical observatory dome and would stand out silhouetted against the sky. The cube rotates on one corner and has three entrances that spin along a track allowing access even when the structure is rotating. The three entrances bridge across the uninhabitable zone that the telescope floats above. Set into the ground, only approximately 2/3rds of the cube is visible from a distance.

Instead of two giant sliding doors on the structure's exterior like the observatories of old have. Four smaller inset shutters recess back into the form, creating a cross-hair of sorts, allowing the telescope to adjust its pitch while the building rotates.

The structure is meant not only for practical purposes but also to attract visitors, showcasing the unique technology that keeps it aloft.



Observatory in Active Subduction Zone

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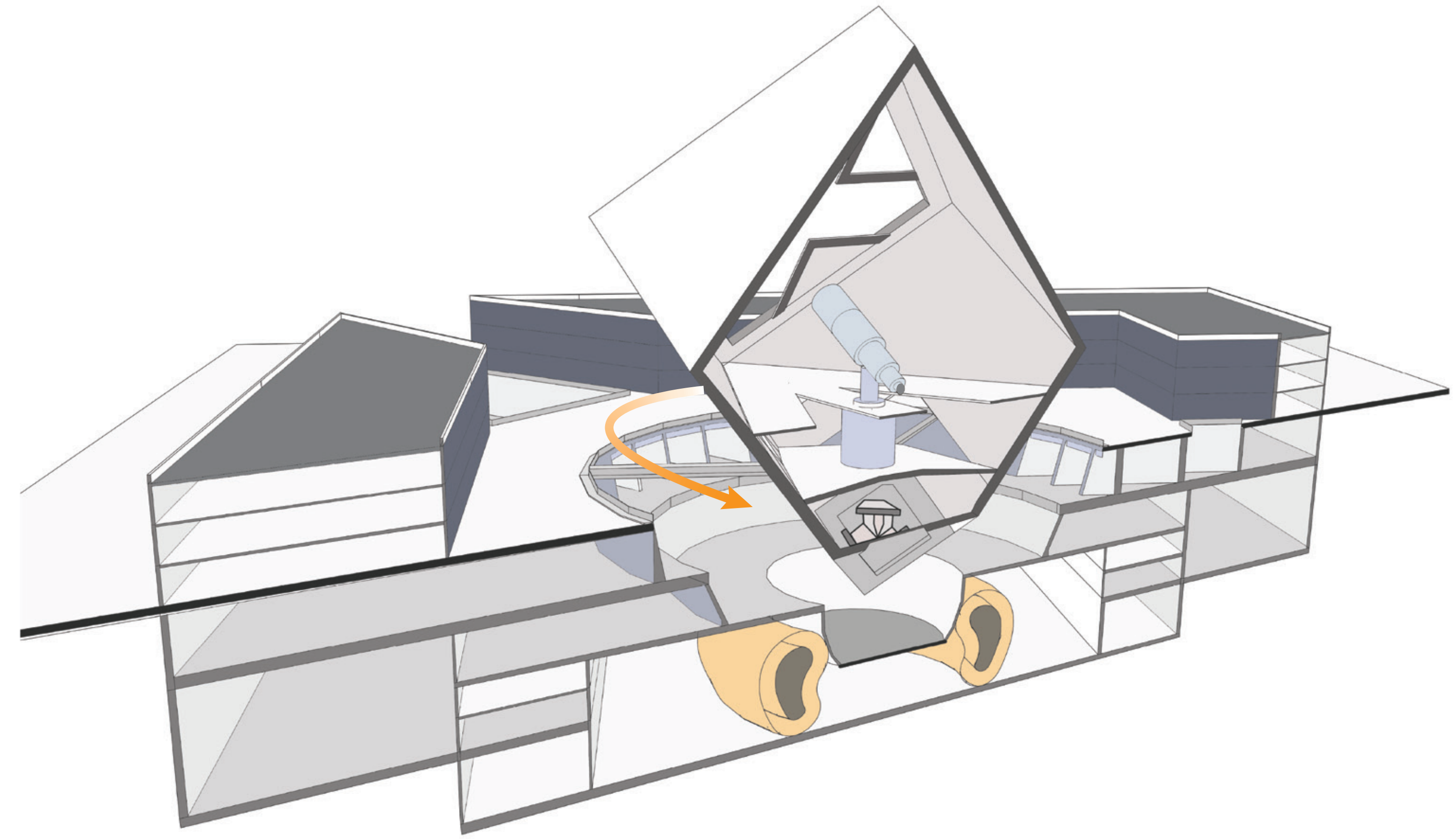
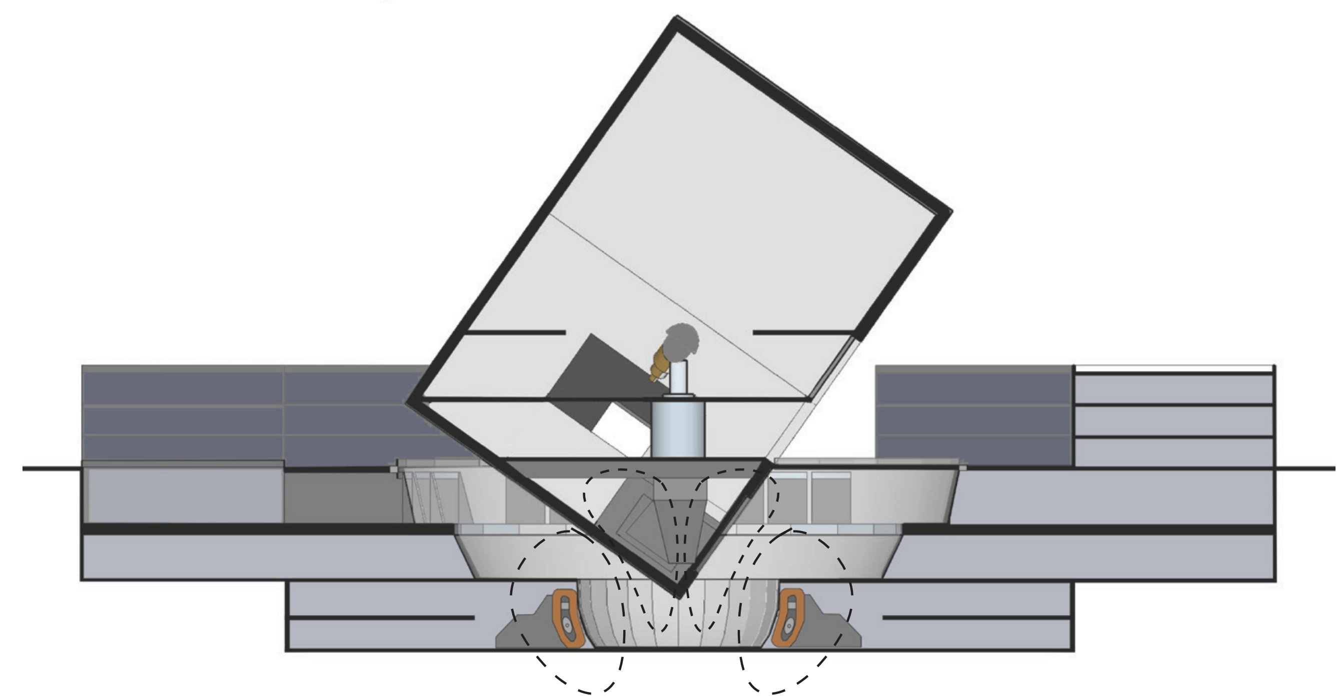
Observatory in Active Subduction Zone





III

Design Cherrettes

Chapter: 25 A New Embassy

While similar to the second project in terms of technical achievement, the main purpose of this design was to showcase the vertical movement and how that could benefit a structure.

Since the structure would be moving up and down over a magnetically inhabitable area, the idea that the structure could close itself evolved into the idea of security. Isolating the structure from the seismic meant not only immunity to earthquakes but also from listening devices and underground infiltration.

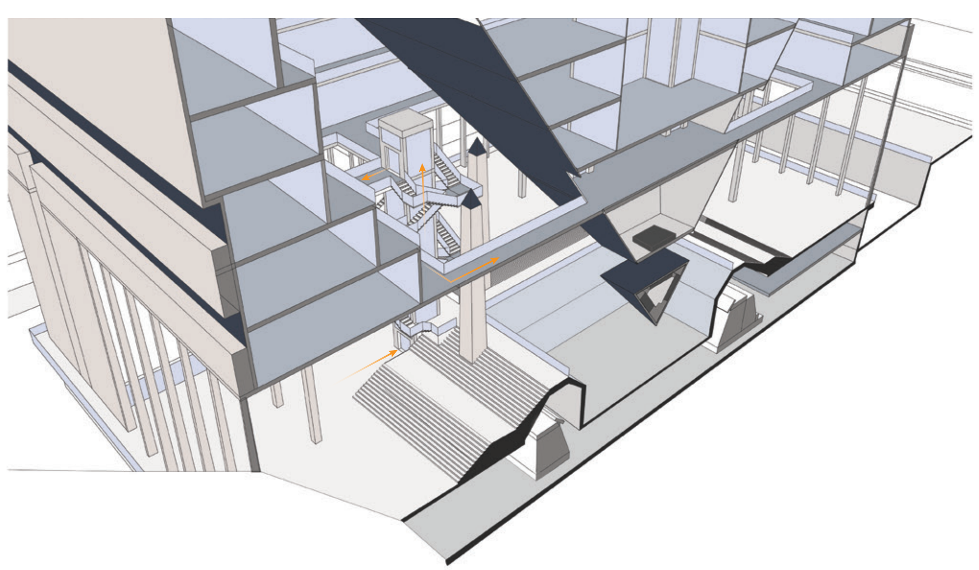
With the recent move of the Egyptian Government to their new administrative capital and the past attacks on embassies in the area, this proposal suggests a new approach to embassy design.

While Egypt's move to their new planned city of broad avenues and projections of power is controversial, the city itself seems to be mostly taking shape as a large portion of it is already done and moved into.

The new embassy is meant to be secure yet open to the general civilian population of Egypt so that the average person can wander onto the site and discover for themselves what America is about while at the same time maintaining private embassy function and projecting US Power.

Fitting the Ancient Egyptian Theme of the rest of the City while Still maintaining the American motief, The structure hosts a massive inverted pyramid inspired by the back of the dollar bill.

Using the electromagnetic function to regulate power output, the entire central inverted pyramid structure can be lowed to block the entrances, locking down the entire building and cutting off access to the upper floors. Creating On-Demand public to private space.



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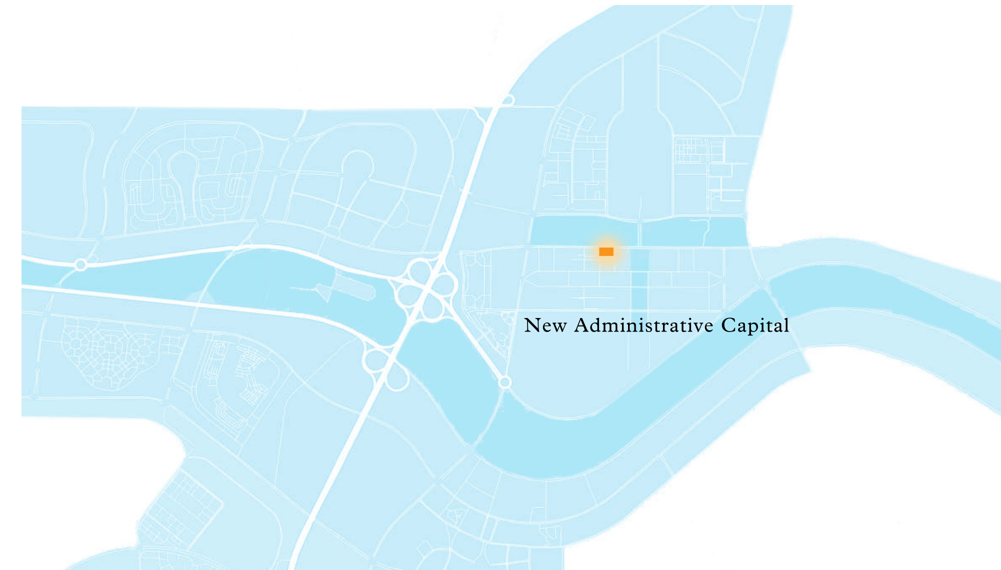
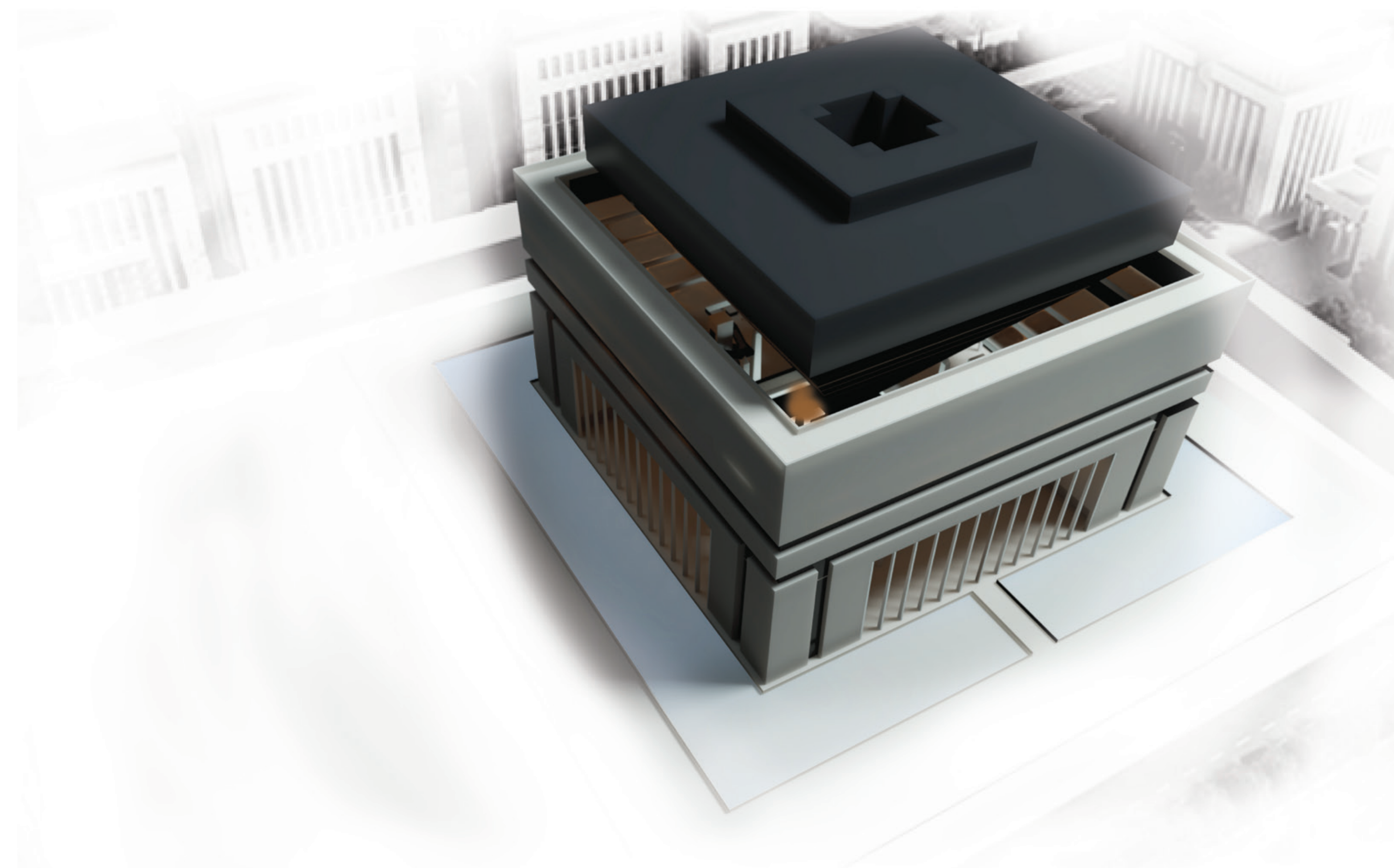
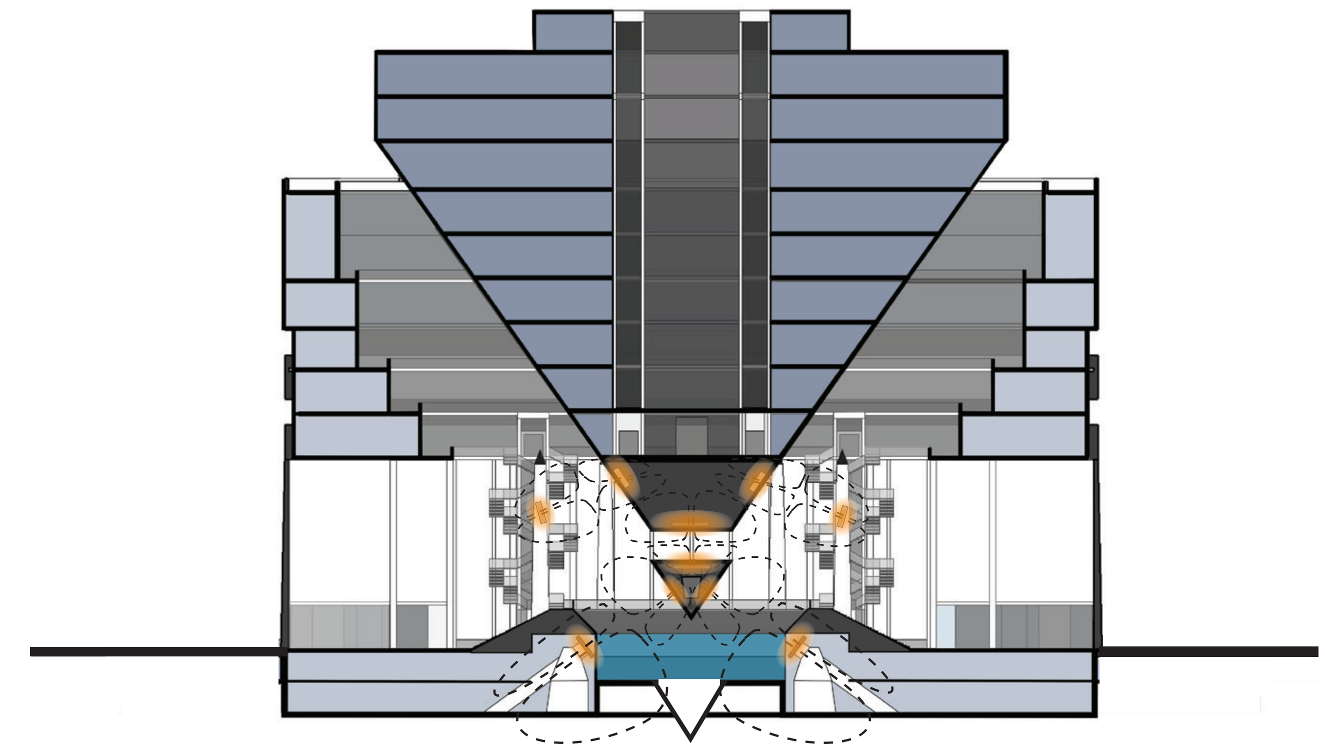
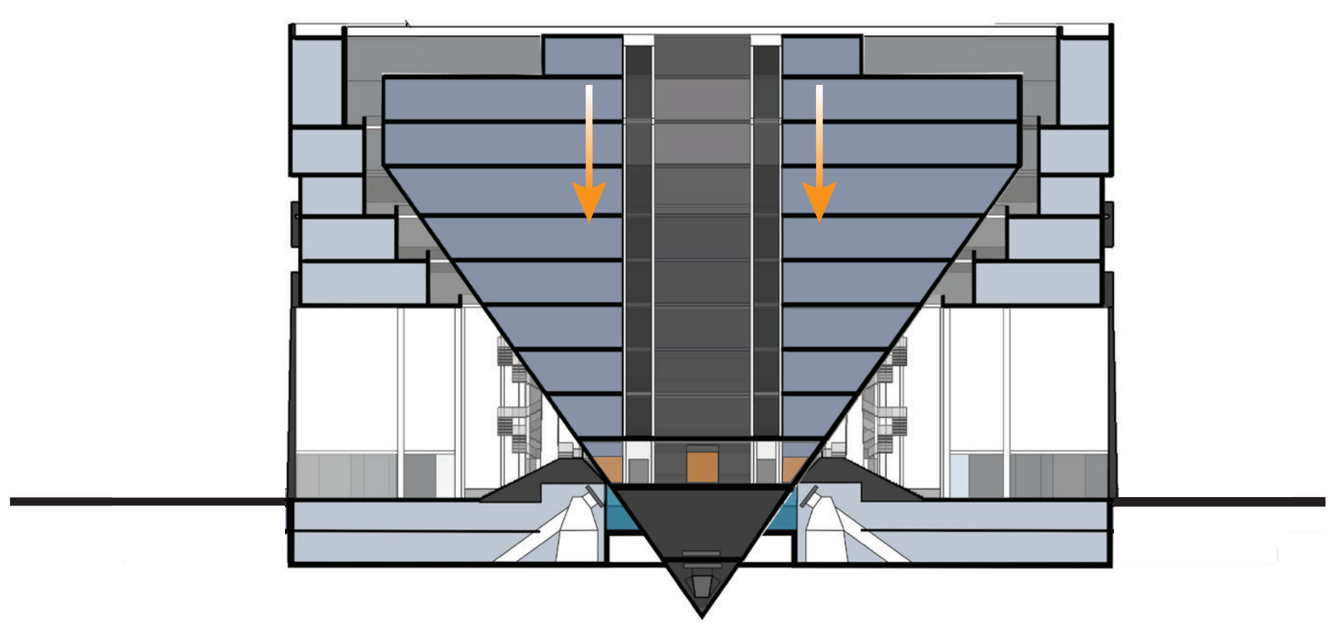




Dynamic Embassy in a Dynamic State



MAGNETIC FIELD EXTENT



LOCK-DOWN PROCEDURE LOWERS STRUCTURE TO BLOCK ENTRANCES

Keeping Secure in the Public

III

Design Cherretes

Chapter: 26 Building Tall

The Final charrette is a mega tall skyscraper arcology. Arcologies being cities inside of a buildings means that the massive structure houses its own power and water infrastructure and its own city services, such as fire fighting and policing services.

The structure houses various residential, commercial, industrial, and even botanical functions.

The initial design focused on just a mega tall tower with typical commercial functions like office space, retail restaurants, hotel functions, and residential units scattered throughout the different floors.

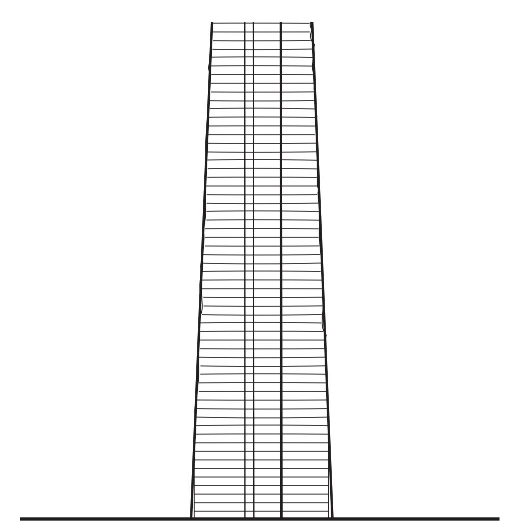
The initial focus of the design was to test the possibility of the electromagnetic systems in general. The building still used massive amounts of concrete, which made it extremely heavy, and the structure of the building had to be narrowed at the base to transfer

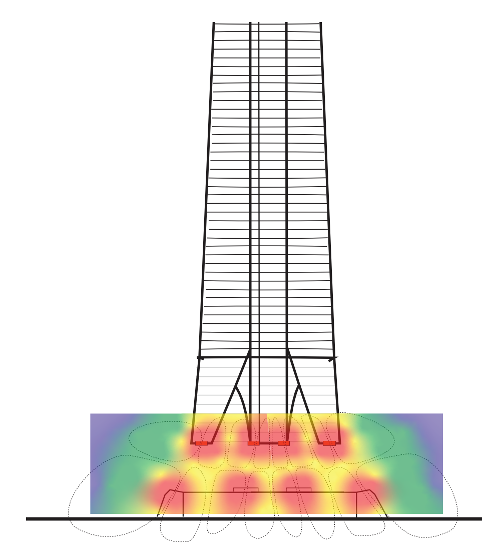
At best, the load into the magnetic arrays was an iffy structural decision and probably wouldn't work in reality.

Moving forward, I chose a different structure to make things a bit easier. Using some of F Kahn's diagrams, I decided on the yet unbuilt Conjoined super framed towers to be the structure for the mega project, shortly after noticing the amount of space that this type of structure could provide, moving the project more toward the arcology aspect.

Admittedly getting distracted by the idea of an arcology The next section will focus on this distraction of planning all the systems that fit inside the building to make it an arcology.

Image: (i56) NOAH (New Orleans Arcology Habitat)

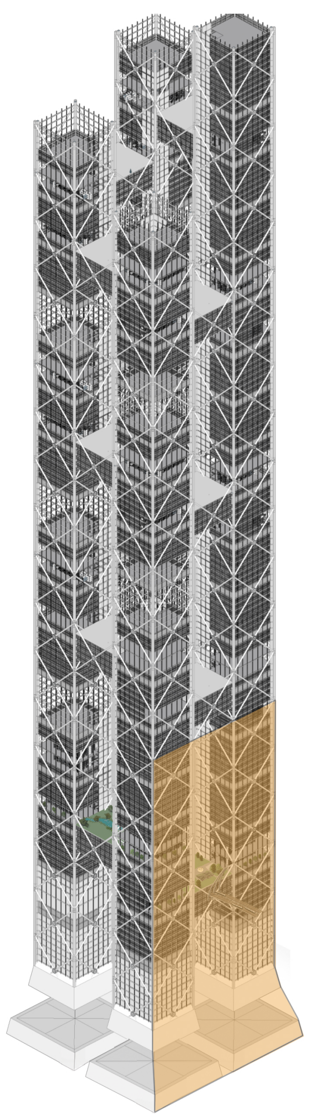




References: (i56)   Kevin Schopfer

The project was early on, set in the waters around New York, an expansion to the city proper, and a response to the ever-growing number of people working from home during the 2020's pandemic. Set in the late 2100s, the project was accessible via rail from a large viaduct over the supermassive electromagnetic field that it would generate. The Idea of the structure and why it was so big was to provide a semblance of a street scape inside of the building, the conjoining structural bridges located every 300' would be focal points for residences atop them would be large green spaces that would reflect the local climates and elevation depending on the elevation they sat in the arcology itself.

On the first main entry floor, which sat over 900' above the water, people, after departing the rail line, would exit through an Olmsted inspired park, the two towers connecting the Park would be mostly city services with some commercial and residential up top, below which sat most of the buildings electromagnetic systems. The two towers to the south, which would only be accessible by going up and around then down, would house in building power generation consisting of eight small modular reactors in the southwest tower and water treatment in the southeast, as well as fire department drone deployment for fighting fires inside the structure if need be.



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After 300' of a mix of residential and office space, the 2nd conjoining bridge would be based on a northern swampland ecology, with the same mix of residential, commercial, and office space, as well as the start of interior vertical farms with artificial lighting.

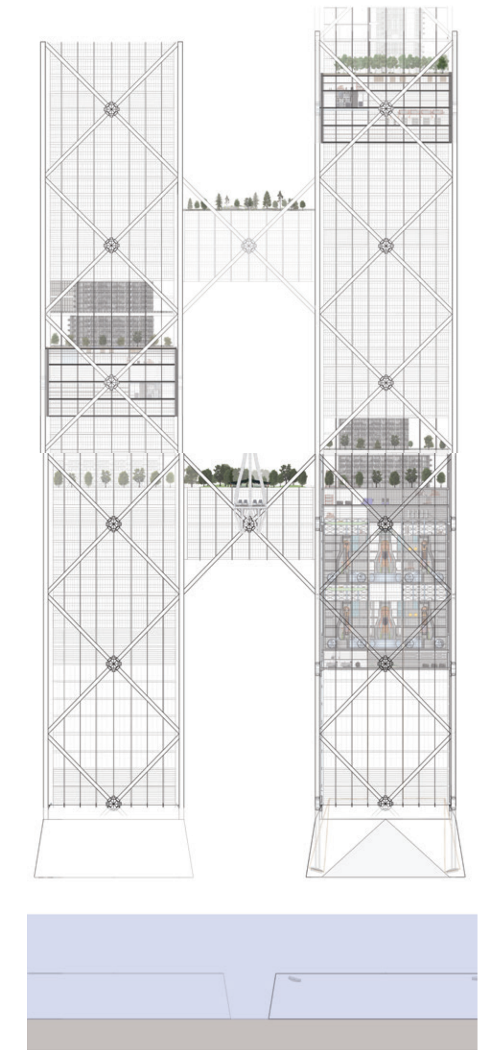
The 3rd Conjoined bridge would have an upstate New york ecology consisting of a more rocky terrain that one might find at the base of the Appalachians.

On the fourth bridge, a paper birch forest with low ground cover, these examples would continue covering a variety of North American and Canadian ecosystems scaling with elevation and location of latitude.

To avoid massive amounts of the floor space being taken up by elevator cores, the MULTI elevator system would be used to create a variable highway in the sky of elevator cars crisscrossing across the sky bridges and moving people to the exact floor they want inside the structure.

A larger imagery of the lower 1800' can be found earlier.

After this initial design, I moved the structure around New York in different locations to see how such an enormous thing would be integrated into the city grid or off it. I would, however, modify the design and would start work on the final version, which would be more of a massing than an in-depth study like this version of the project had been and focus more on the magnetic aspect.



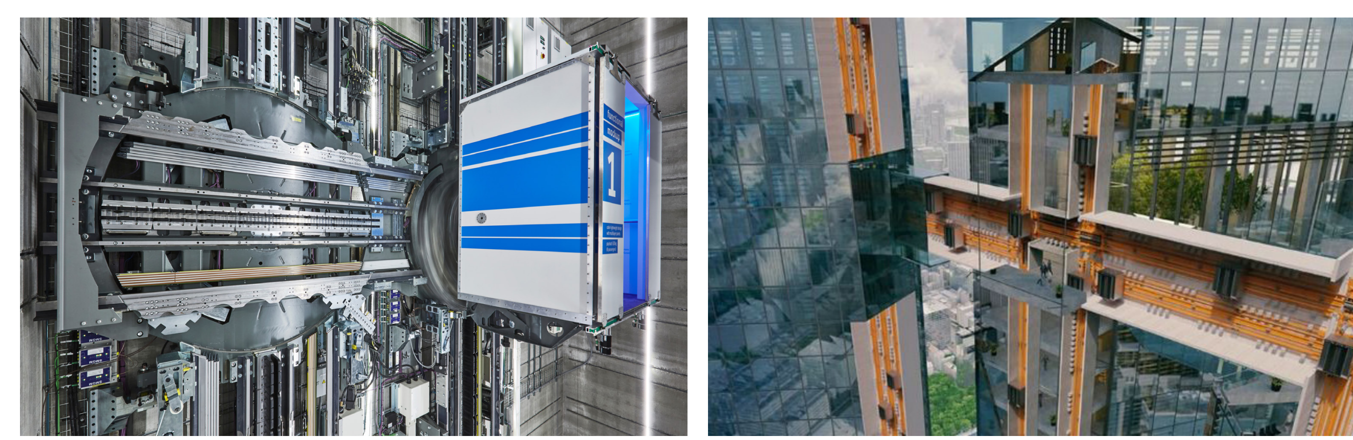
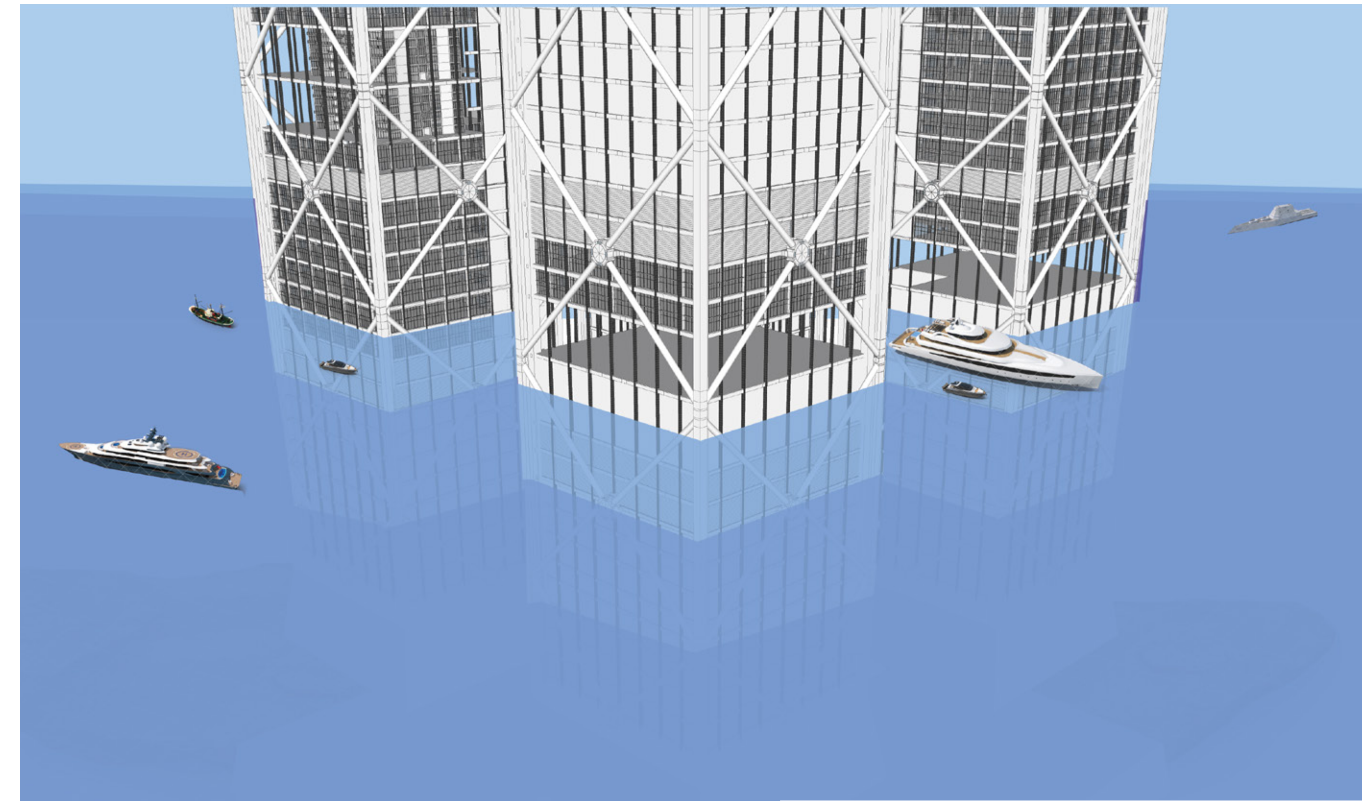
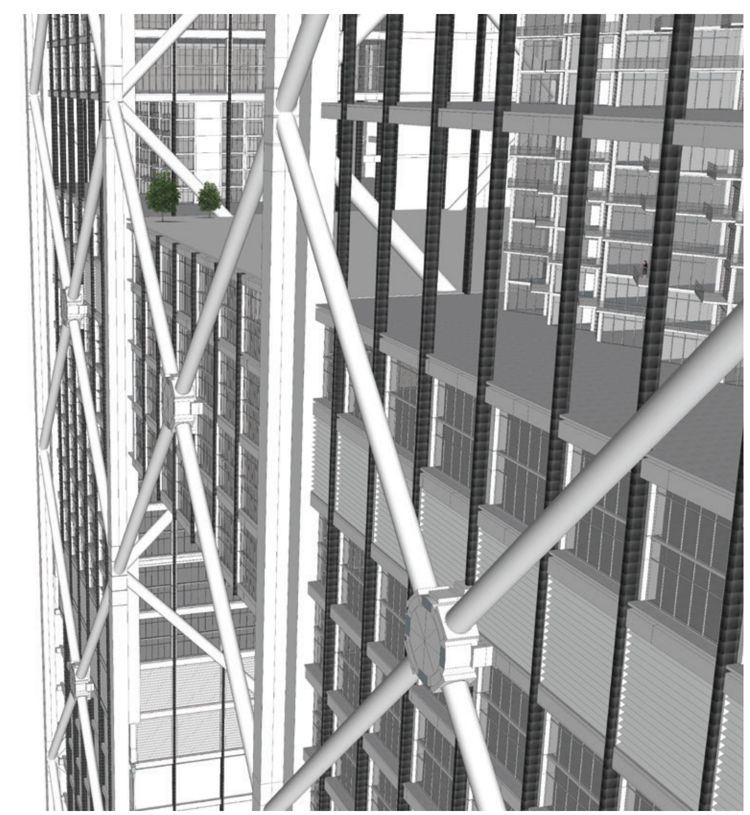
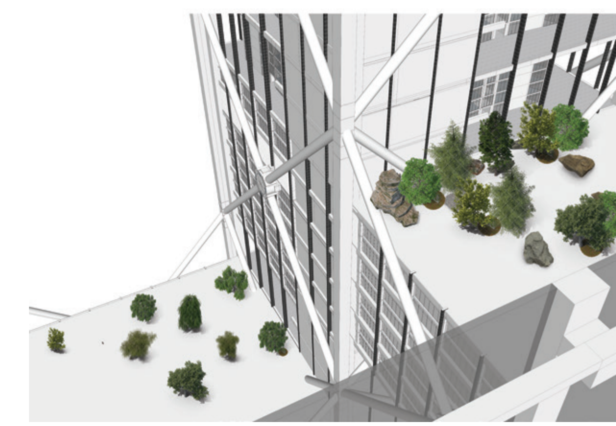


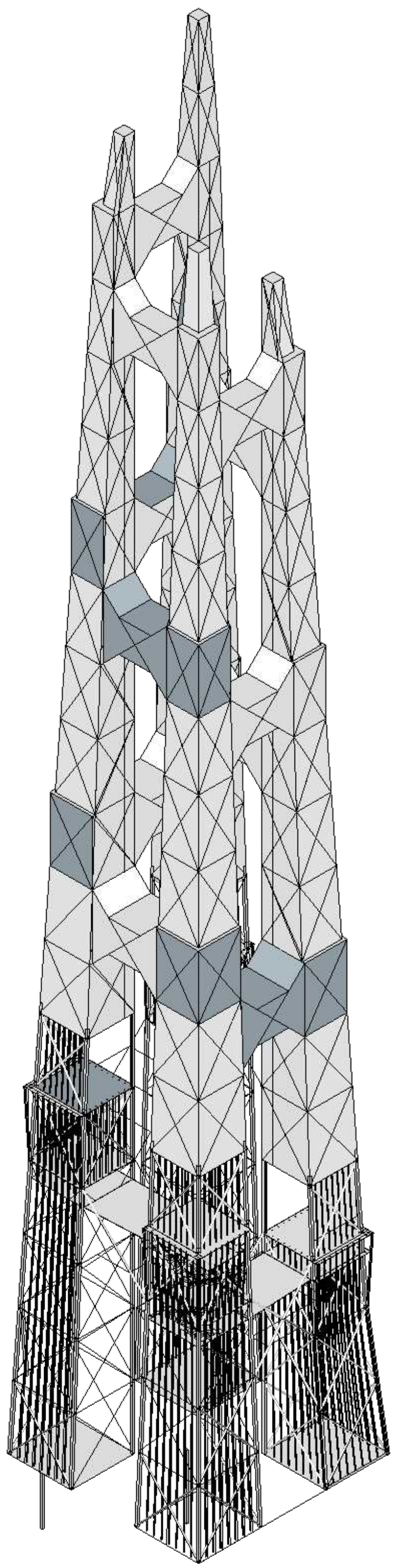
Image: (i57) MULTI elevator system by ThyssenKrupp

References: (i57) https://www.tkelevator.com/global-en/products-and-service/multi/







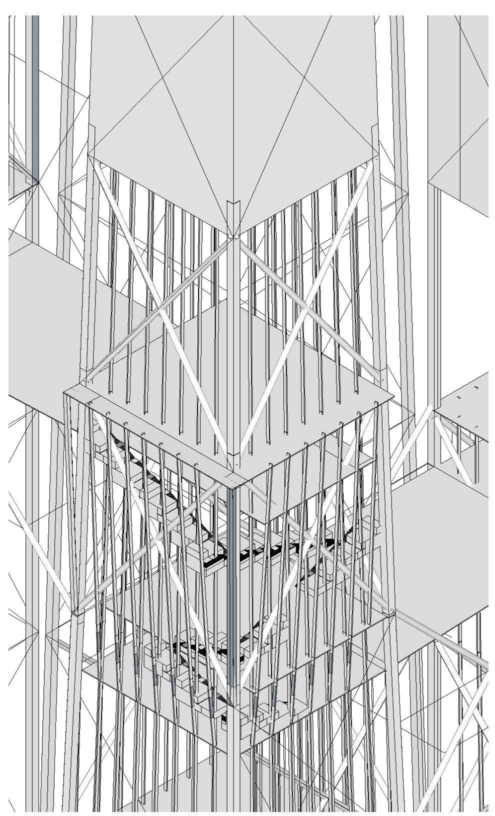


The new form of the structure narrowed toward the top to further reduce the weight of the structure as well as, allowing light to penetrate farther into each floor as well as changing the interiors of the lower levels to focus on a more industrial and vertical farming model, neither of which requires natural light.

While I wouldn't expand much on the detail in this version, some thought was given to the experience if one would want to climb the entirety of the structure.

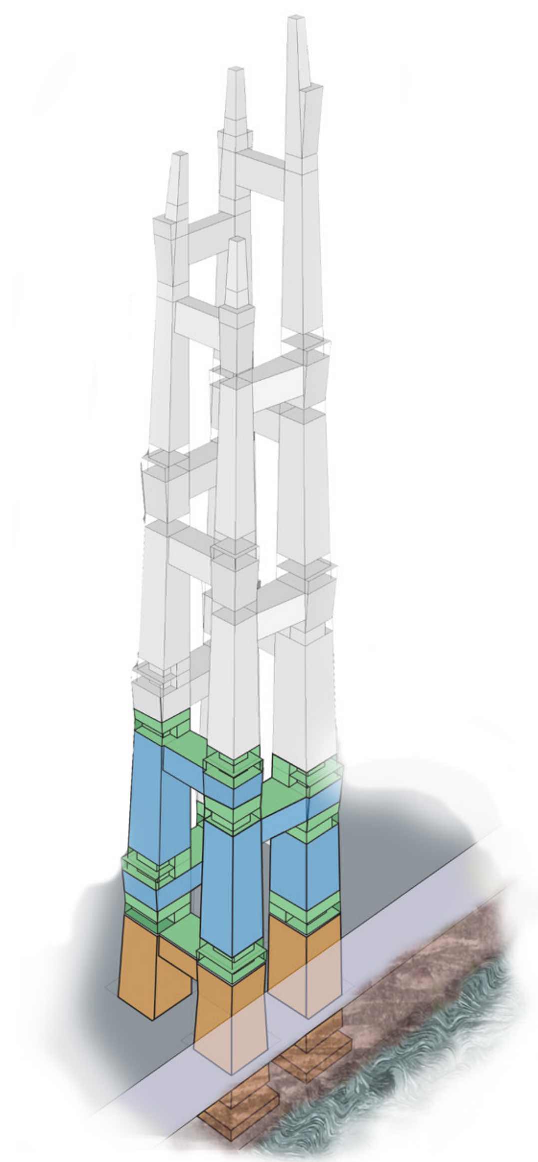
The tower would then lose a lot of the detail as I realized my architectural want to detailed was getting me distracted, and I would focus less on programming and structure and more on the massing and what and where the magnetic systems in the structure were.

The mega tall arcology would then be moved to New York's upper bay and be partially sunk to allow more accessible boat access instead of just one rail line to the tower.



Firstly focusing on what would become the base of the structure where the magnetic systems would be toned down to spreading the load horizontally and directly to bedrock, replacing concrete and steel with power and the magnetic field.

The other focus would be smaller magnetic systems on each key structural floor that regulates a smaller field allowing the structure to regulate sway at an individual elevation level.



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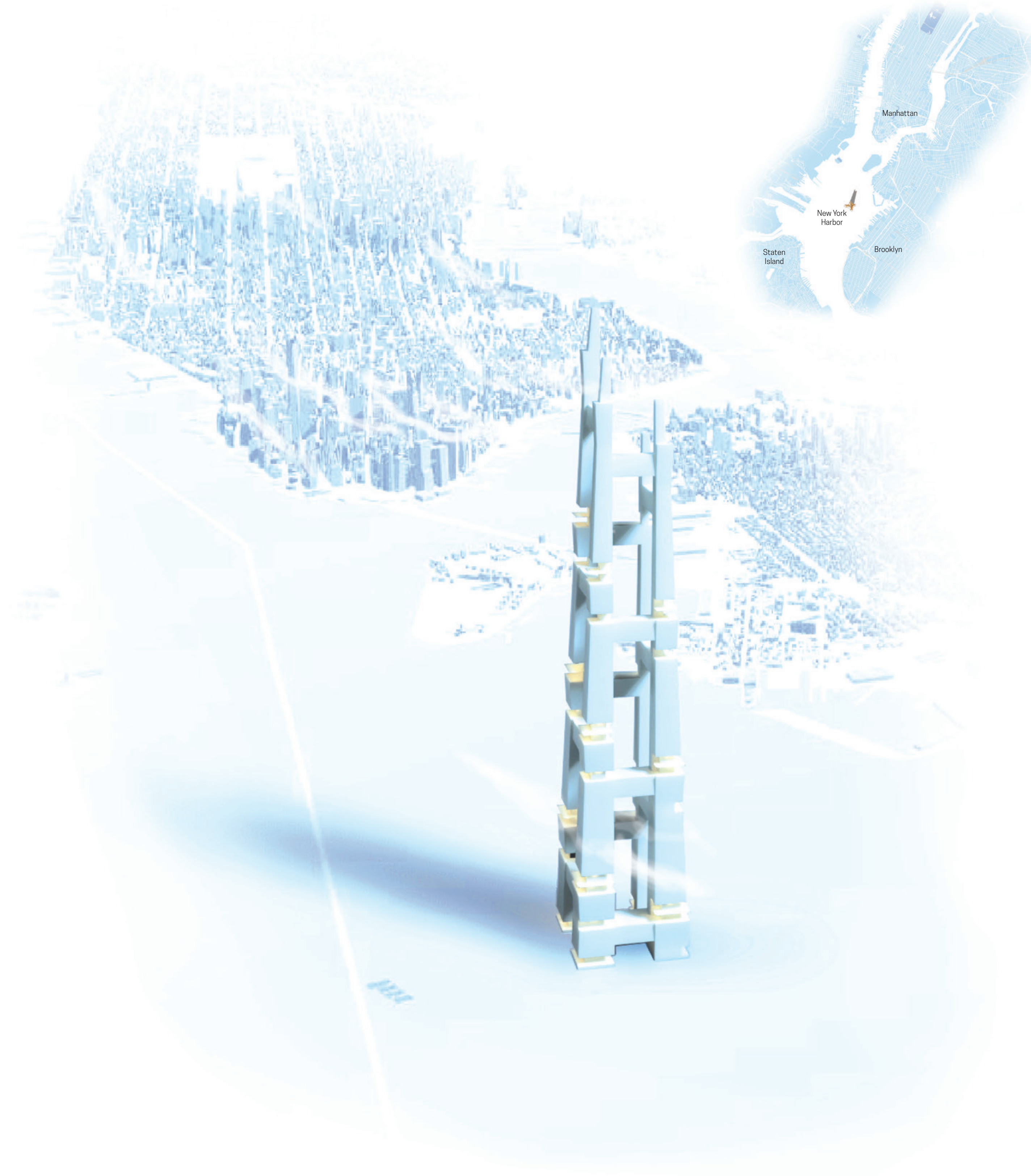
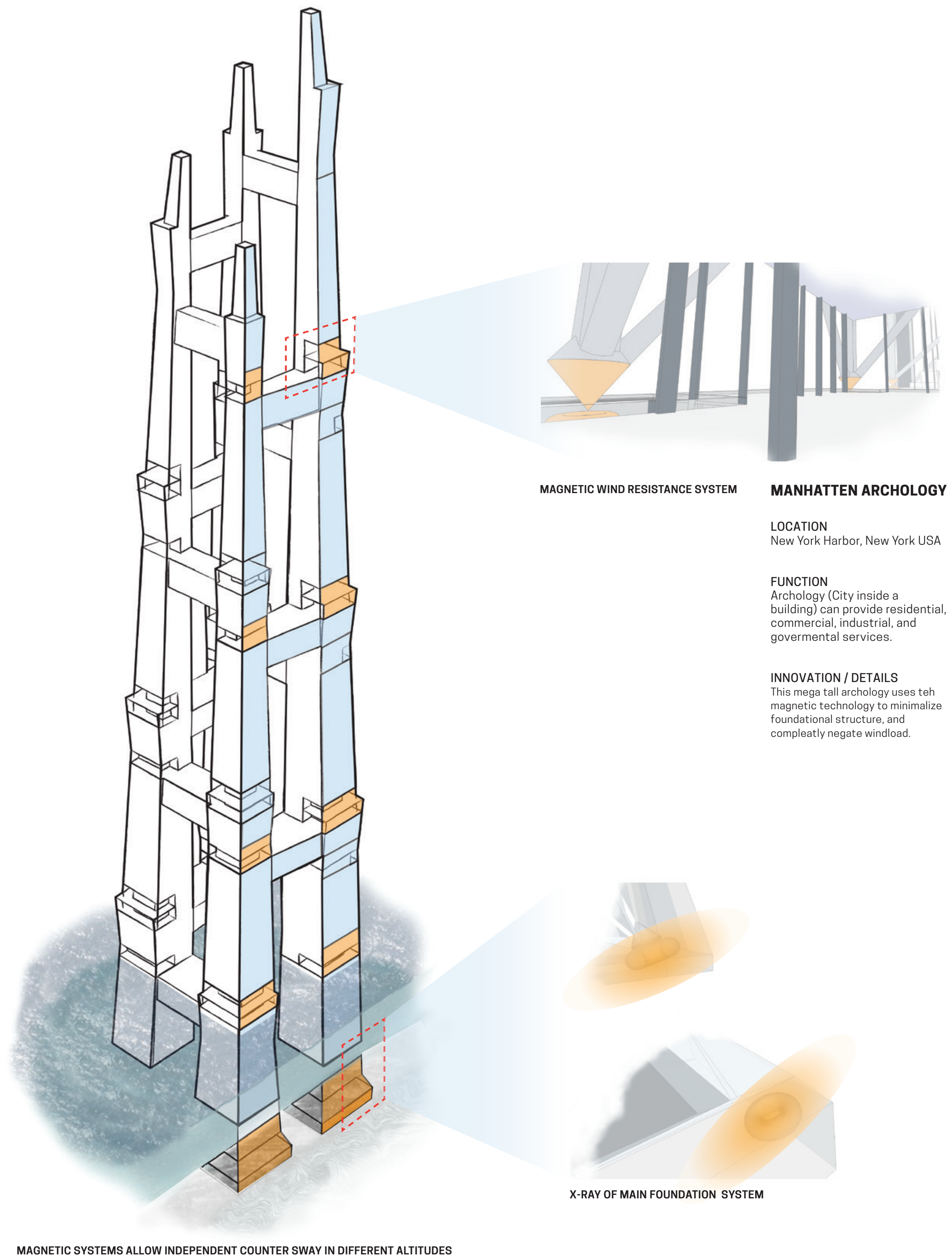


New York Archology Project



Replacing Concrete with Power

IV

Conclusions

Chapter: 27 Conclusion

The designs of these charrettes showcase several different way electromagnetic systems could be used at different scales and what kind of typologies would be economically appropriate at these different scales.

This by no means that these types of projects are the only possible structure that magnetics could be used in, or even that they are the easiest to use them in. In fact, over the course of the semester, several other projects were started but never came to fruition.

Using magnets to temporarily float buildings during construction or, in one of my sketch ideas, temporarily using the magnetic technology to quickly jack buildings, specifically in a project idea for jacking the entire city of New Orleans, which can be found in Appendix C.

Another Project that never made it past the sketching phase was the idea of a movable stadium that the seating of stadiums usually stays about the same for any sport and only the field and equipment change, so having a levitating stadium that moved from field to field was thought of but the idea never fully flourished.

While the uses of the electromagnetic technology in this book is well explored, the math itself is admittedly not fully understood by me, and it could be that these structures could need to use a lighter construction method using materials like carbon fiber or graphene tubes instead of steel and concrete to reduce the weight and load farther.

The major critics of the systems in this book remains the public's skepticism as to the safety of occupying such a structure, as well as the massive power consumption.

Circulation is another critics as to showcase the even for future standards expansive technology the levitation of the technology would most likely be on display by order of any decent architect and not hidden. This means that circulation over the uninhabitable zone of the structure is problematic from a design standpoint, as the uninhabitable zone has to be visually there to create the wonder that the absence of any physical form can make. Too small an entrance might limit capacity, while too large and we risk hiding the focal point of the system, that being the levitation portion; getting that right in terms of the scale of the building will be tricky for future architects to deal with.

I will admit these charrettes are more of a medium-scale regarding what the technology could be used for. However, the small-scale examples can be found in the current day's maglev train and furniture designs that were discussed in chapter XX. These medium-scale projects provide a middle point to the distant future of the mega-scale space infrastructure development discussed in chapter XX.

From the historical perspective from the beginning of the book, while I didn't completely conform to my precedence of typologies over time, the process did inform my work. The Bearing Strait bridge project, if the electromagnetic technology becomes feasible, will most likely be one of the first permanent structures to be built using it due to its very nature of only having people cross it and not worry about living on it.

So, in conclusion, I hope that the Sci-fi like wonder of levitating architecture can appeal to a broader audience and that this book is used in the future in some capacity by an architect to design them.

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V
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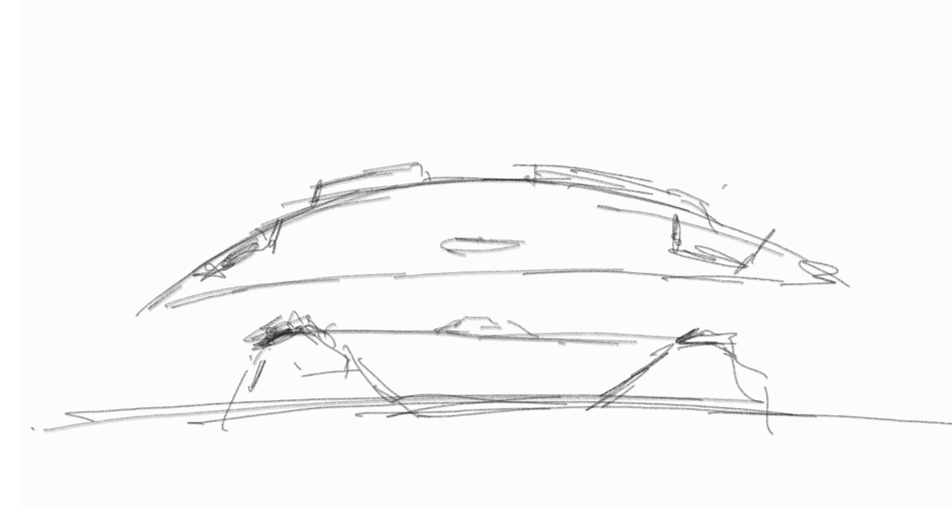
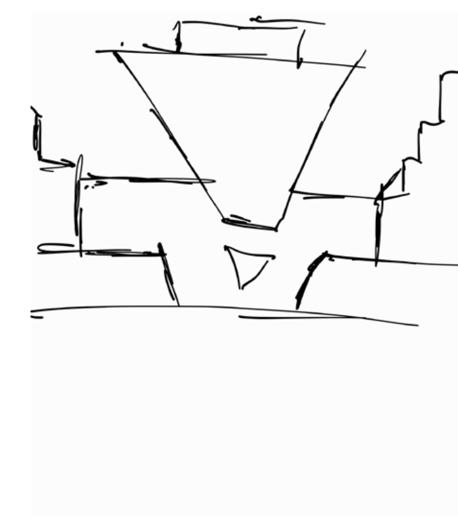
V

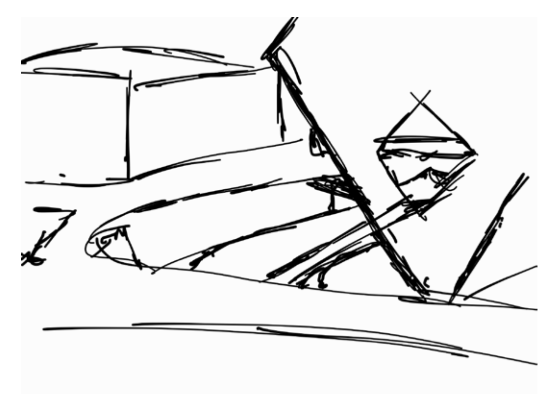
Appendix B

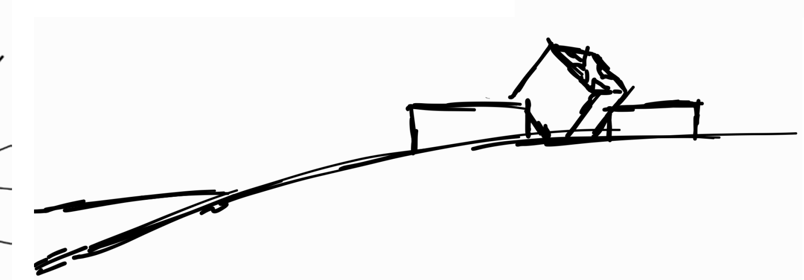
Initial sketch Ideas

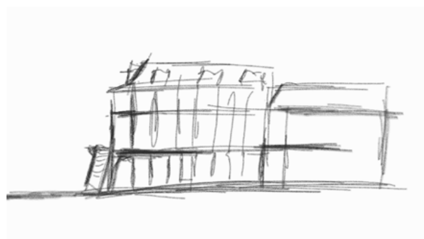
Bearing stright bridge Sketch

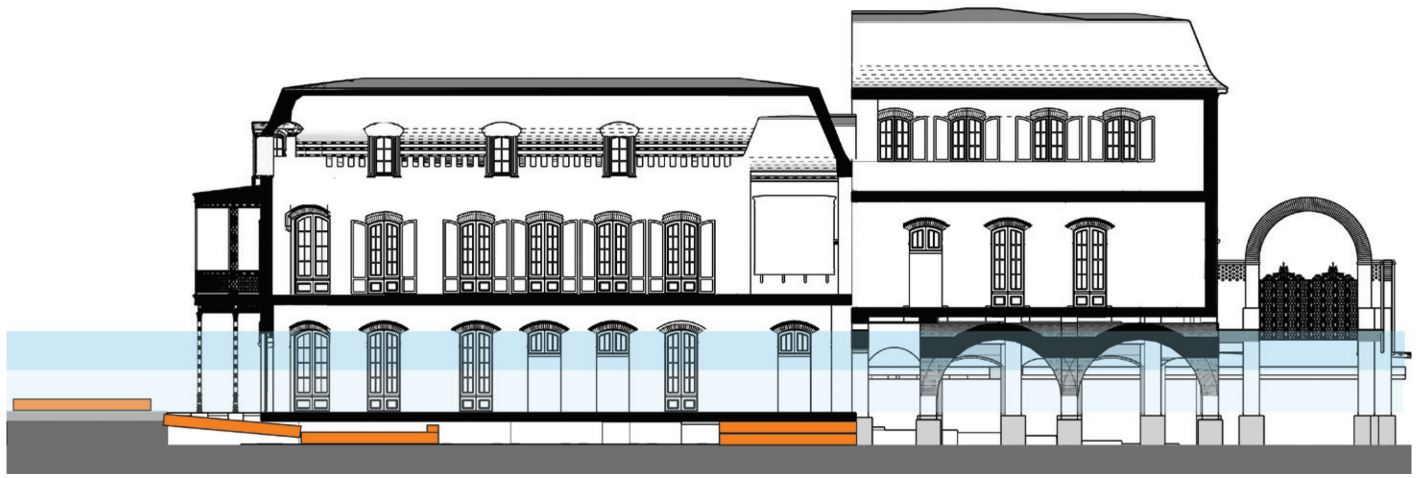


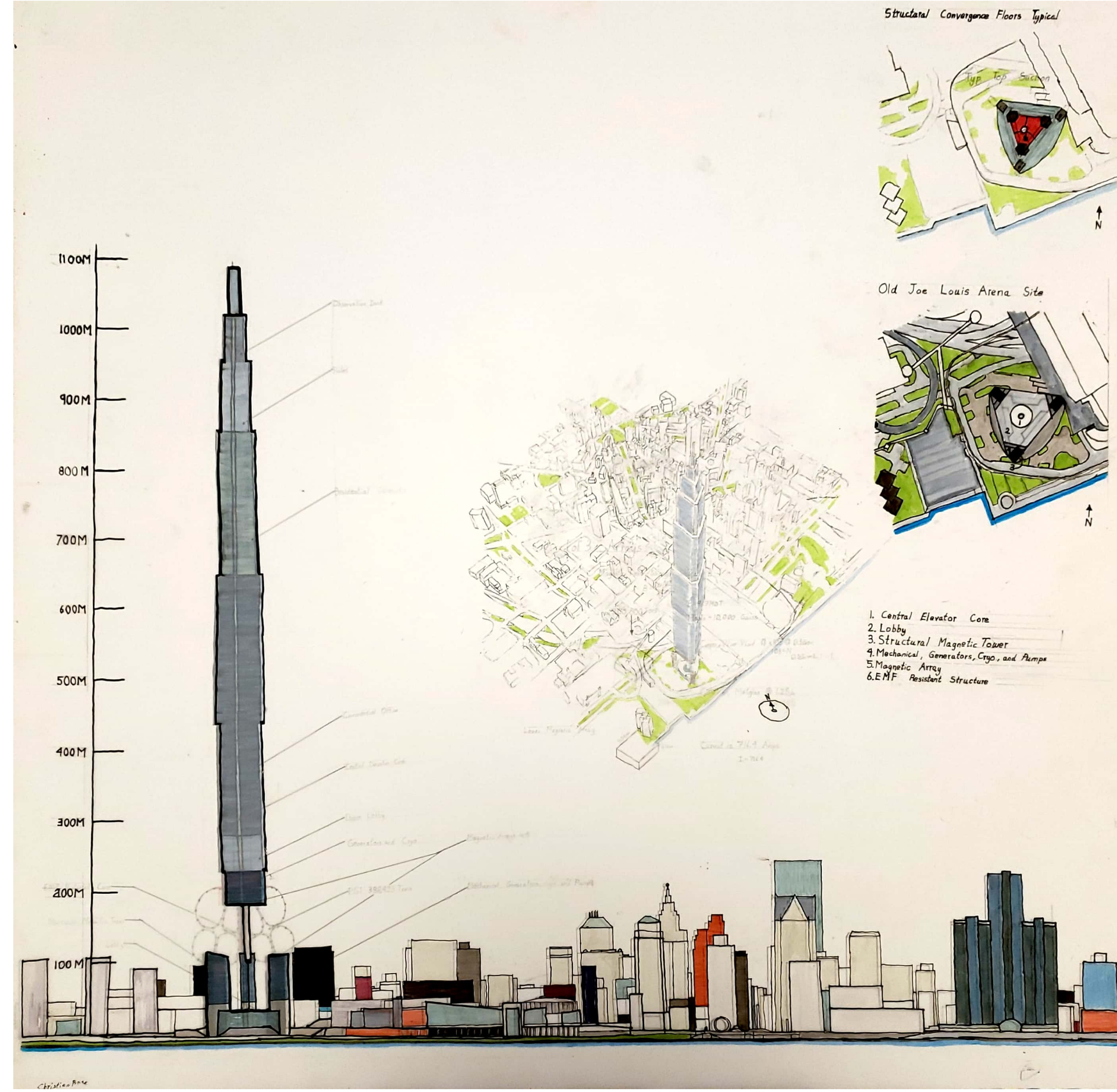


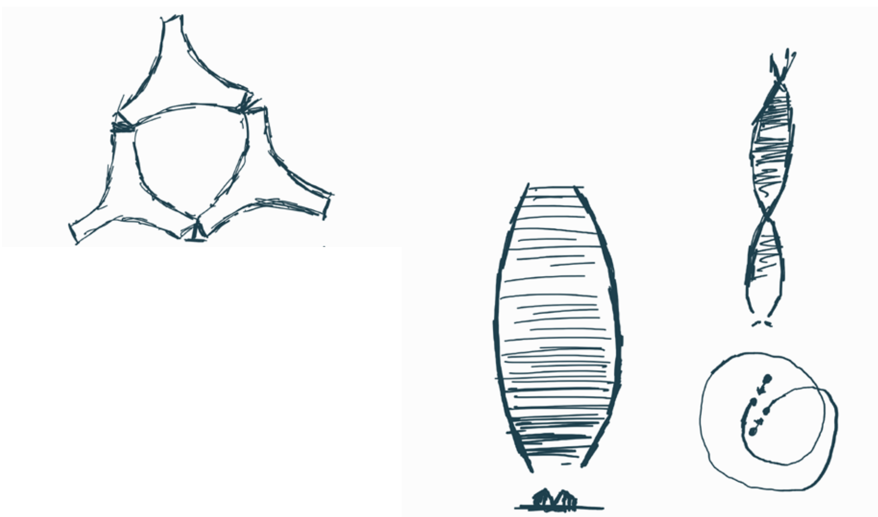


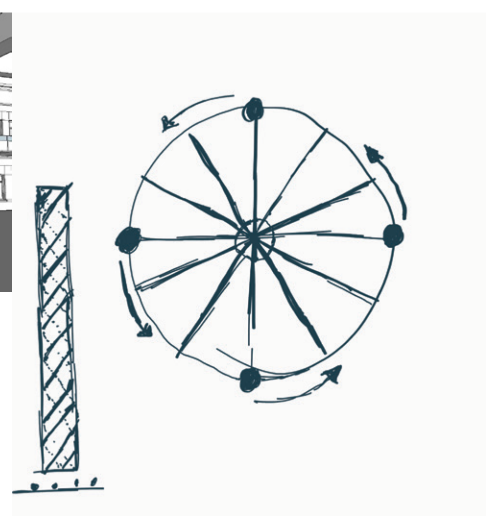


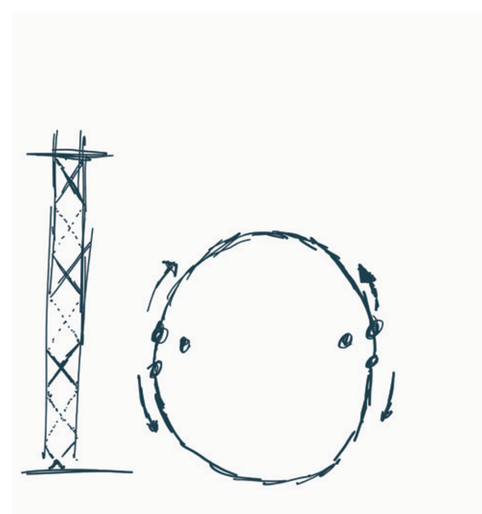


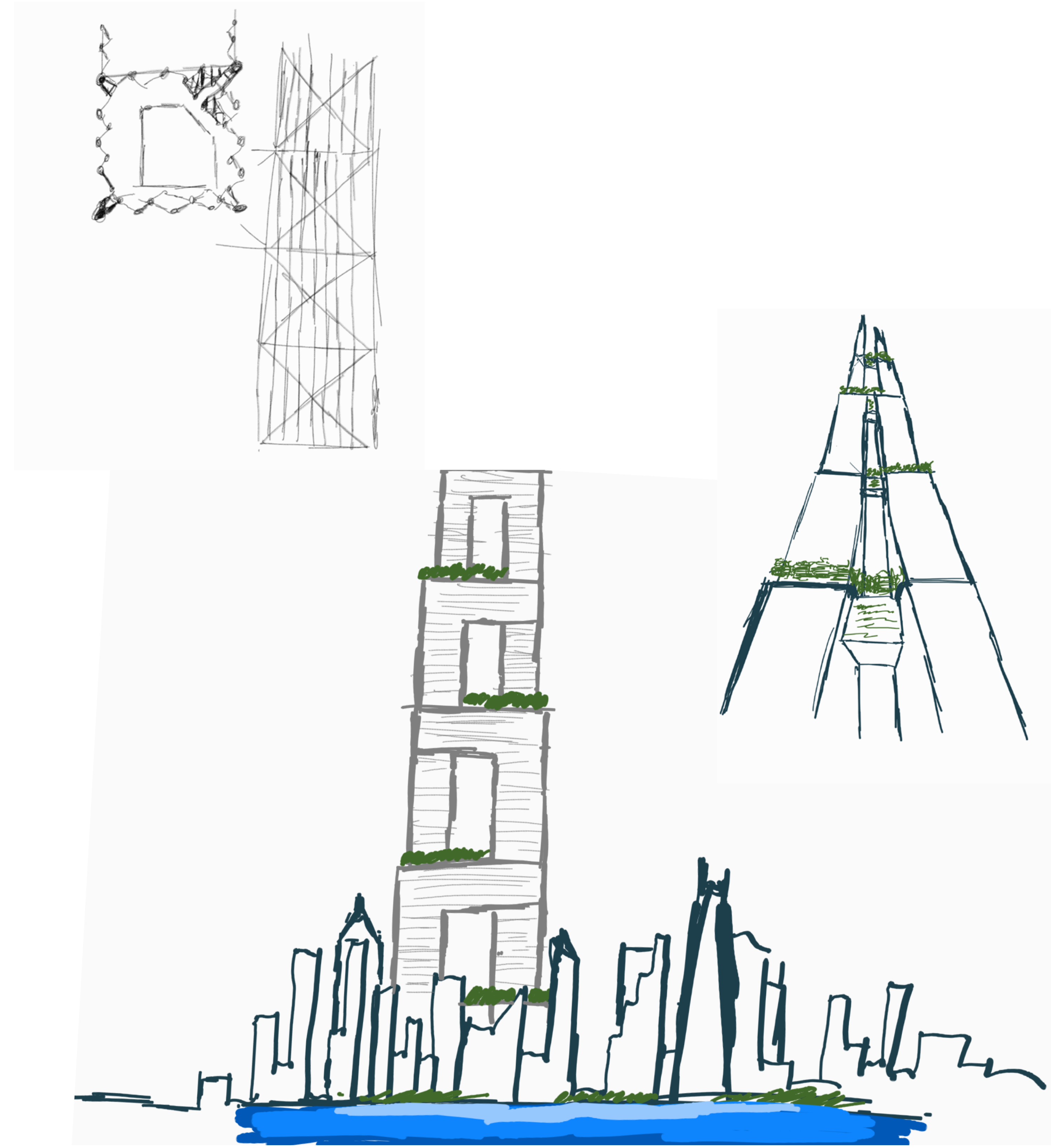


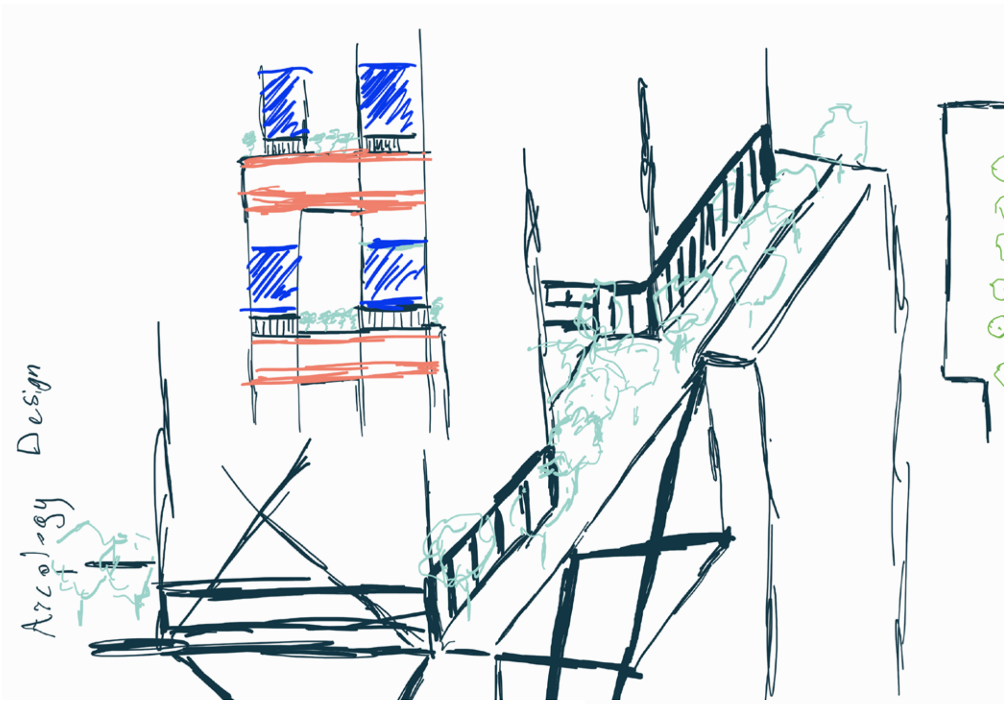

Structural Convergence Floors Typical
N
Old Joe Louis Arena Site
N
1100M
1000M
900M
800M
700M
600M
500M
400M
300M
200M
100M
1. Central Elevator Core
2. Lobby
3. Structural Magnetic Tower
4. Mechanical, Generators, Cryo, and Pumps
5. Magnetic Array
6. EMF Resistant Structure

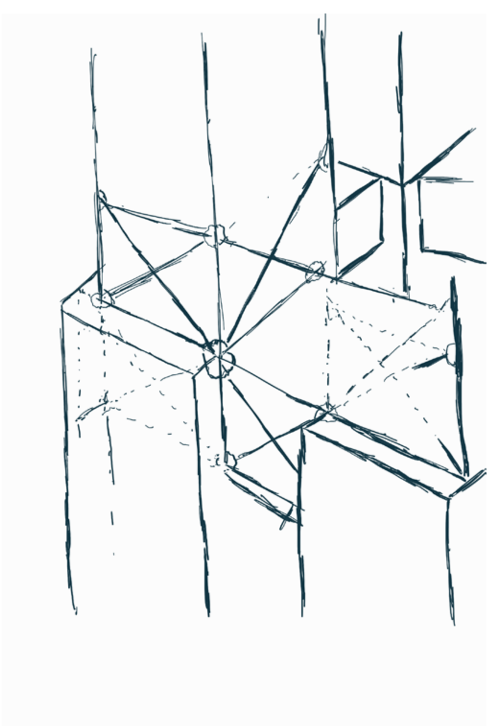


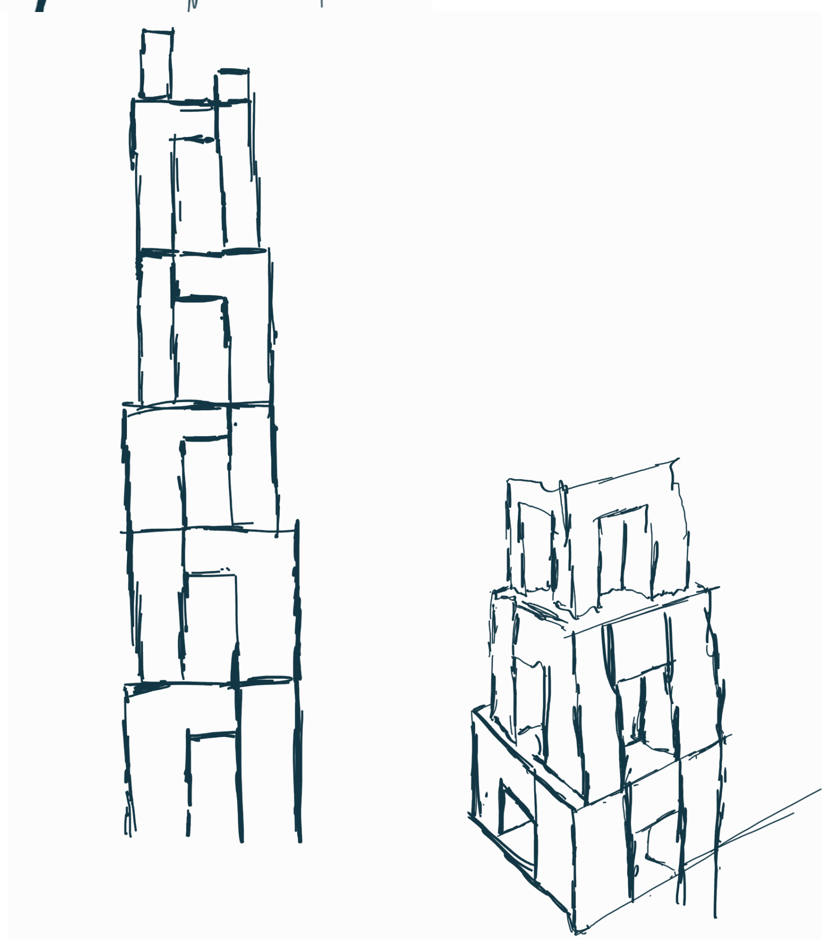


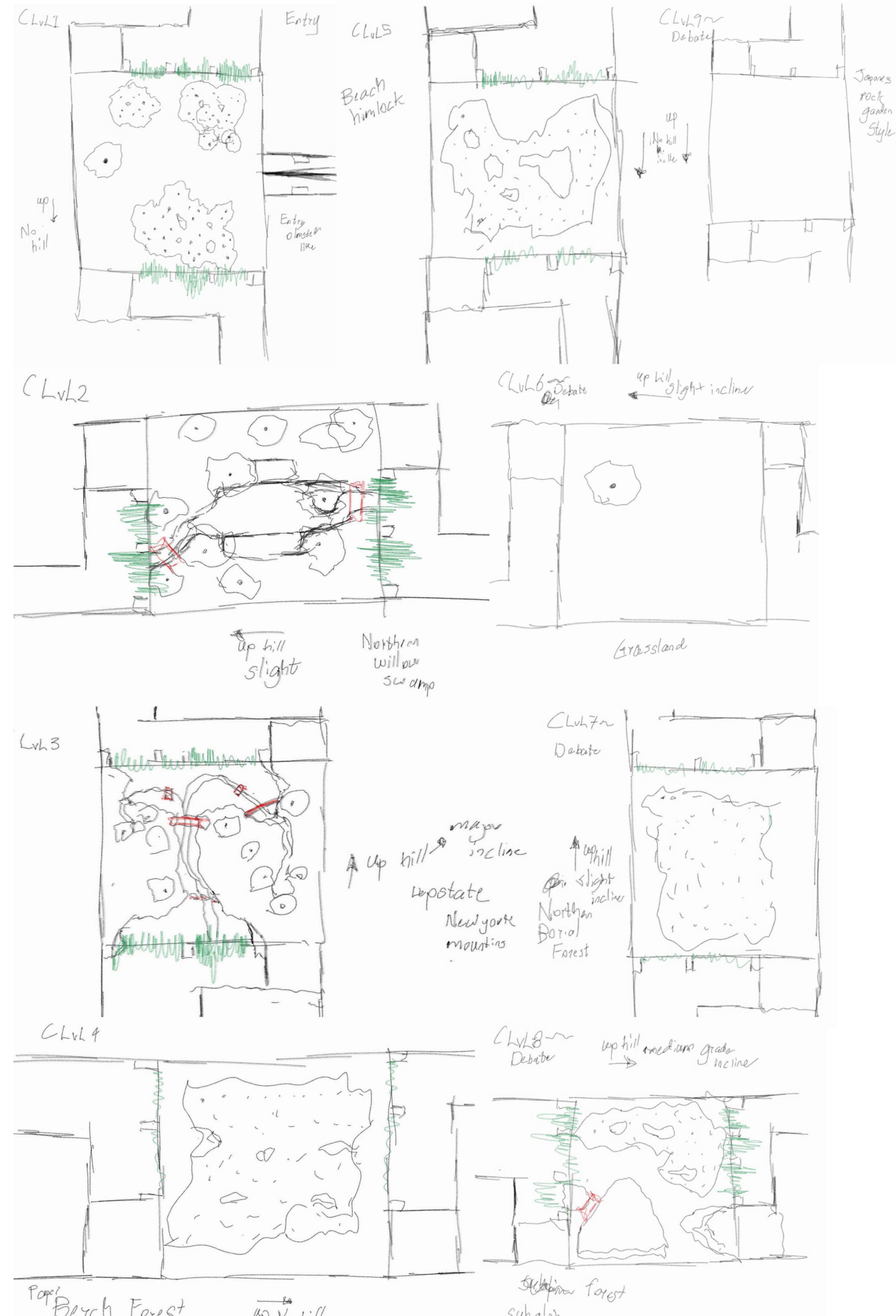


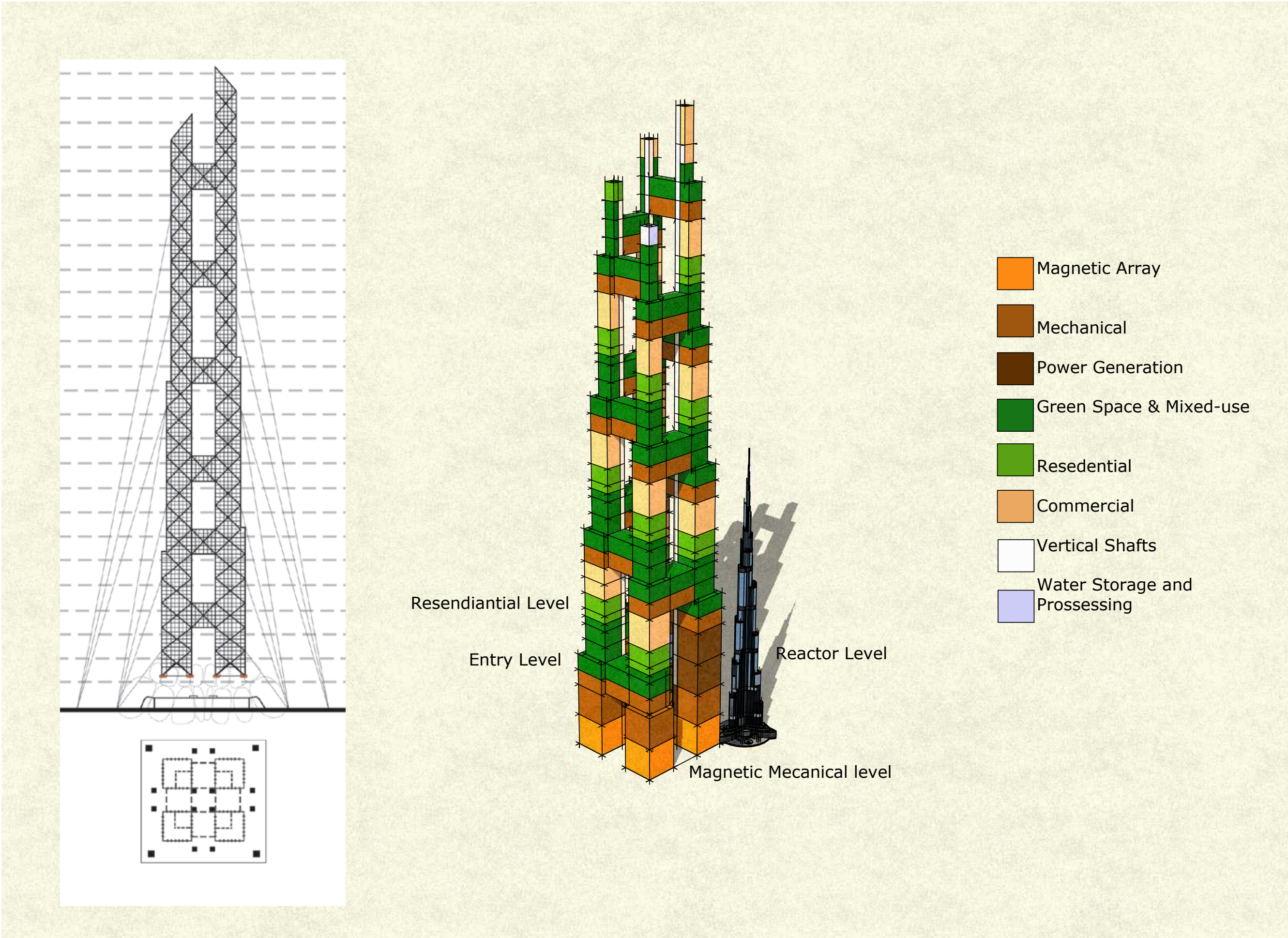


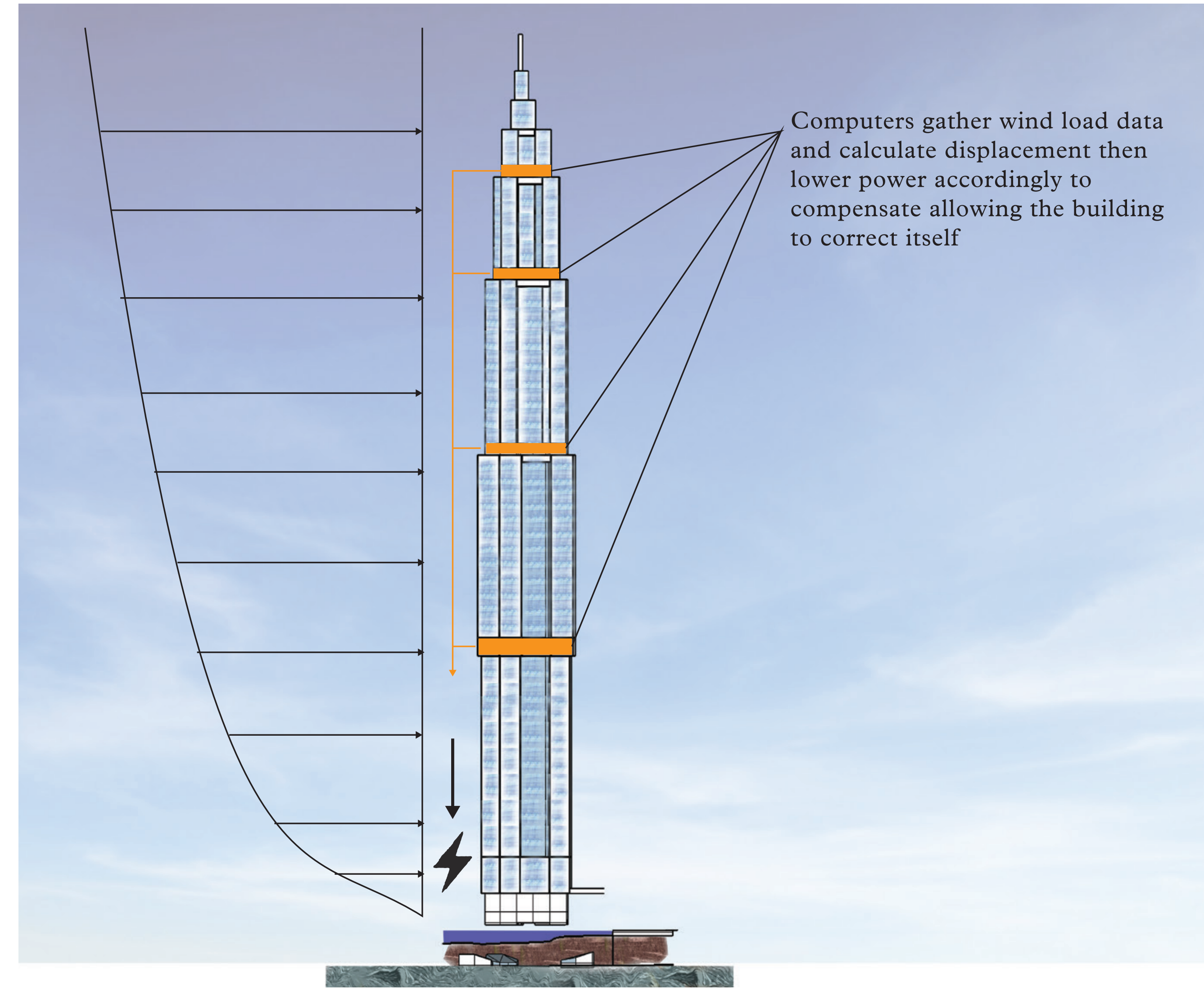

Arcology Design

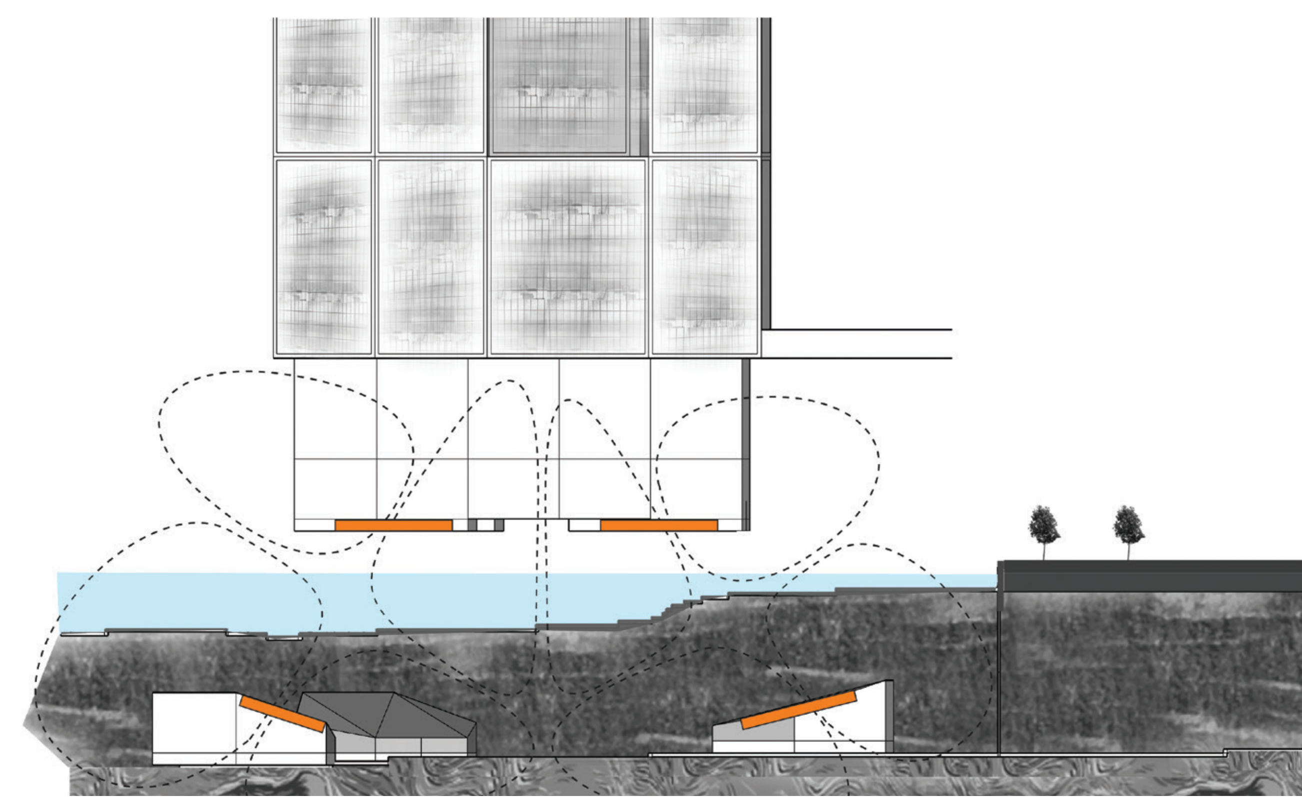


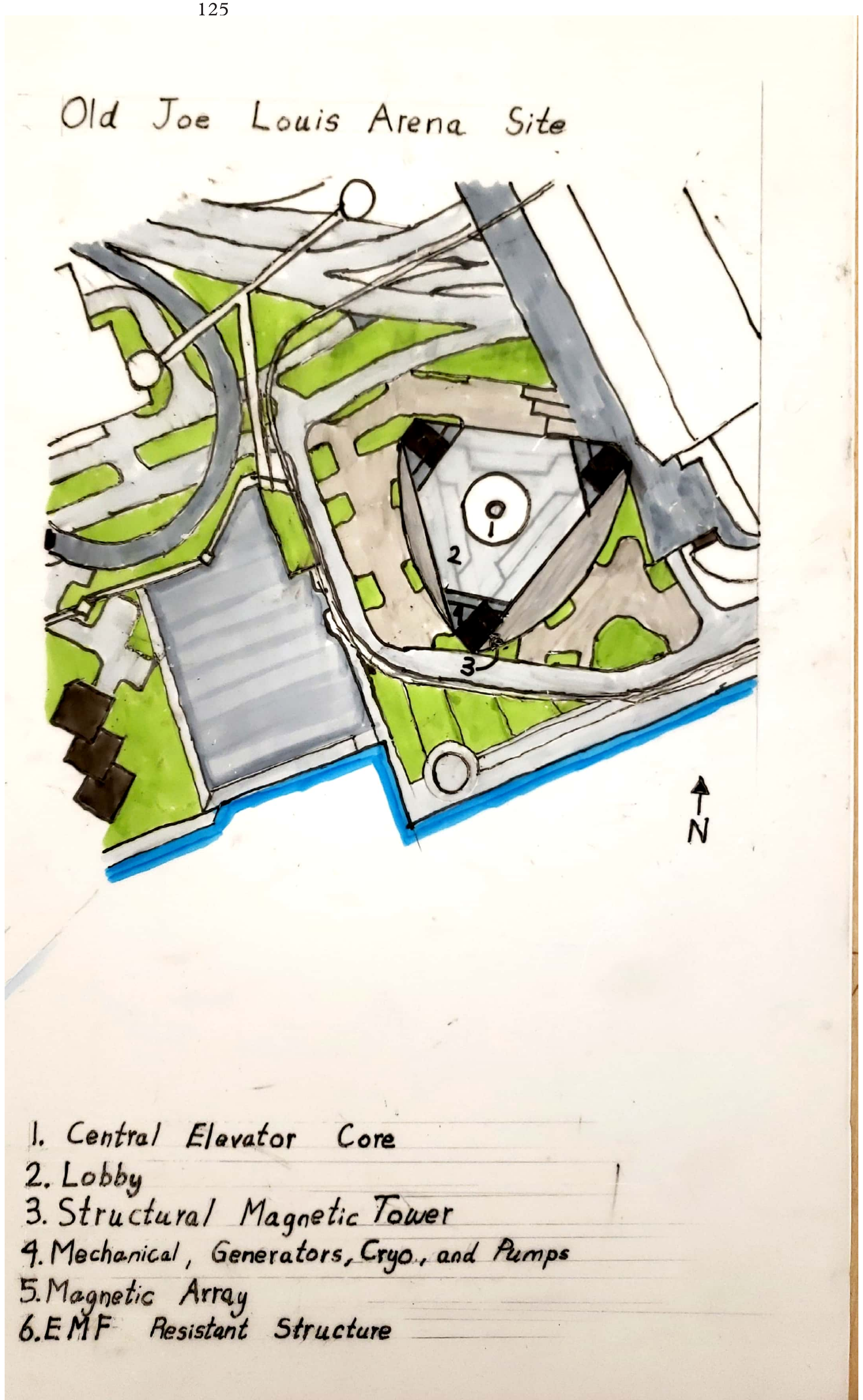



CLvL1
Entry
CLvL5
Beach himlock
CLvL9
Debate
Japanese rock garden Style
CLvL2
up hill slight
Northern willow swamp
CLvL6
Debate
up hill slight incline
Grassland
LvL3
up hill major incline
Upstate New york mountains
CLvL7
Debate
Northern Borial Forest
CLvL4
Beech Forest
up No hill
CLvL8
Debate
up hill medium grade incline
Subalpine Forest


Magnetic Array
Mechanical
Power Generation
Green Space & Mixed-use
Resedential
Commercial
Vertical Shafts
Water Storage and Prossessing
Resendiantial Level
Entry Level
Reactor Level
Magnetic Mecanical level


Computers gather wind load data and calculate displacement then lower power accordingly to compensate allowing the building to correct itself




Old Joe Louis Arena Site
N
1. Central Elevator Core
2. Lobby
3. Structural Magnetic Tower
4. Mechanical, Generators, Cryo., and Pumps
5. Magnetic Array
6. EMF Resistant Structure


Lower Magnetic Array
Current is 716.4 Amps
N

Abstract

Throughout history architects as well as engineers have sought to find solutions to the humanities problems through the built environment. All professions have or will influence architecture in some way either directly or through the very nature of one's own profession itself. To consolidate all the information from all different professions and peoples for whatever any given project requires and combine that information with their own expertise's be that artistic, efficiency, both, or everything in between. Keeping this in mind a dialog between the magnetic sciences and architecture does not exist for these new and experimental technologies. This book seeks to lay the ground work for a guideline for an architect's interaction with Electromagnetic systems in the built environment.