Human Engineering

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Human Engineering

A Design Thesis Submitted to the
Department of Architecture and Landscape Architecture
of North Dakota State University

By

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In Partial Fulfillment of the Requirements
for the Degree of
Master of Architecture

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September 2011
Fargo, North Dakota

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Abstract

This thesis focuses on the question: how might ergonomics and universal design improve the human experience in the work environment? The typology for this examination is a research and development facility. The project's location is in West Fargo next to the current Caterpillar manufacturing facility. The Unifying Idea that drives this thesis is: Architecture should be the study of ergonomics, the built environment for the human scale, which should improve human needs. An environment that is consistent with our needs. The justification for this project is: Everyone deserves an environment that meets his/her specific needs. This will, in turn, better society by improving productivity, health, and happiness.

Key Words

Ergonomic, universal design

Problem Statement

How might ergonomics and universal design improve the human experience in the work environment?

Statement of Intent

Project Typology
Research and Development Facility

Claim
Ergonomics and universal design improves human experience through architecture in the work environment.

Premises
"Over the last 30 years, physical anthropologists have been concerned with the documentation and description of human body size variability and its application to design. A significant problem continues to exist.... (Panero, 1979, p. 9)."
It is apparent that in the past the human scale was not taken into account when the industrial work place began in the United States, better ergonomics would improve life in these areas.
Ergonomics applied correctly to its surroundings provides comfort, avoids accidents, reduces stress, and promotes higher functioning levels and overall happier lives.

Unifying Idea
Architecture should be the study of ergonomics, the built environment for the human scale, which should improve human needs; It is environment that is consistent with our needs.

Justification
Everyone deserves an environment that meets his/her specific needs. This tailored environment will, in turn, better society by improving productivity, health, and happiness.

Proposal

Narrative

During my 2011 spring semester, I designed and researched furniture for a Design Build studio. The chairs we made and the way people interacted with my table intrigued me. They interacted with the chairs in ways that I did not design them for, which was interesting. The chairs were designed in such a way in which they were not very comfortable. The typology is an interesting one because when most people think of a research and development facility one thinks of just a large open space in which anything could be placed. But, what if the way this ergonomically designed item(s) was that of the building? The site is right next to Caterpillar's main facility in West Fargo, which is currently expanding its remanufacturing facility to support the mining industry. The surrounding area is very industrial and is very close to the Red River Valley Fairgrounds.

Client Description

The project will be designed and built for Caterpillar Inc. The company, located in West Fargo, currently employs two hundred workers, and it will employ 250 more upon competion of the new expansion in 2012. The new facility will be a research and development factory for new products, which will keep Catepillar competitive and make the overall company more efficient. The building will be designed to meet AIA guidelines so that all people will be able to experience and work here. The building consists of the following: entry, administration offices, conference room, bath rooms, staff breakout, reference library, open planned laboratory, bulk storage, noisy equipment, outdoor testing space, hazardous materials storage, and loading dock. The landscape will be brought back to natural vegetation.

Major Project Elements

Entry
The lobby, the juncture of the whole facility

Administration/Staff Offices
Offices that serve as a base for the full time researchers

Conference Room
Conference Room is a meeting space for the gathering of the workers at the site

Bath Rooms

Staff Breakout
Relaxing space for the researchers

Reference Library
Library space includes a broad range of books and journals with topics pertaining to the research undergone at the facility

Open Planned Laboratory
Large open space with moveable modularized work spaces, benches, and services

Bulk Storage
Storage space for all miscellaneous parts and raw materials for R&D

Noisy Equipment
Somewhat sound proofed room with cacophonous equipment

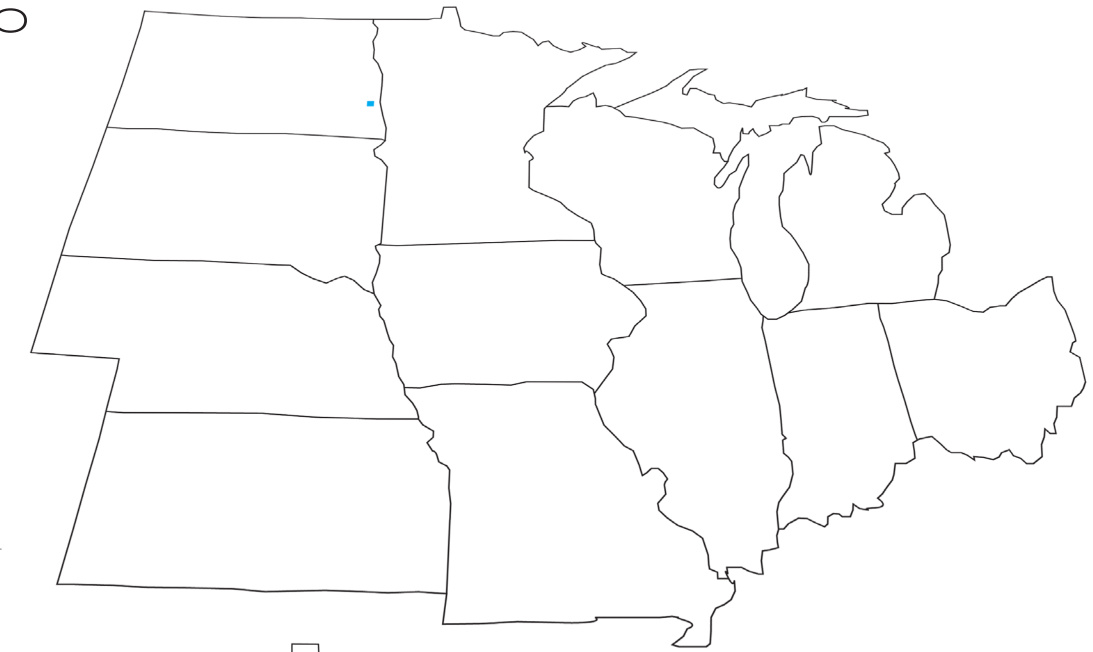
Outdoor Testing Space
An enclosed space for analyzing and testing the concept artifact

Hazardous Materials Storage
A storage space for gases and chemicals

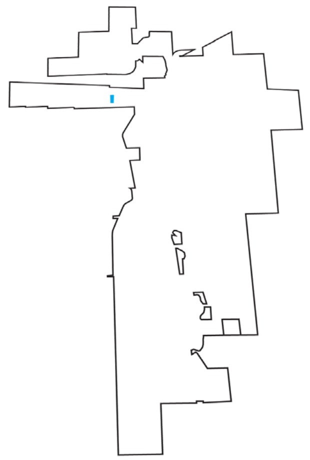
Loading Dock

Site Information

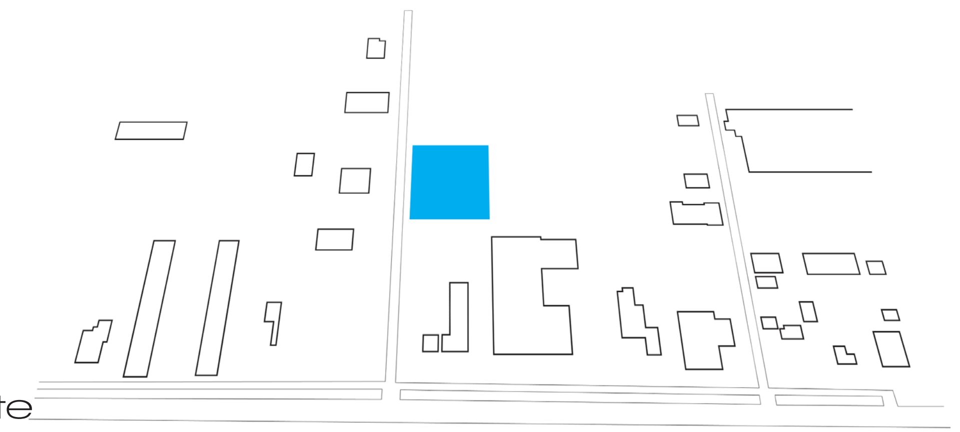
Macro



Region
Midwest



City
West Fargo



Site

Fig. 1

Micro

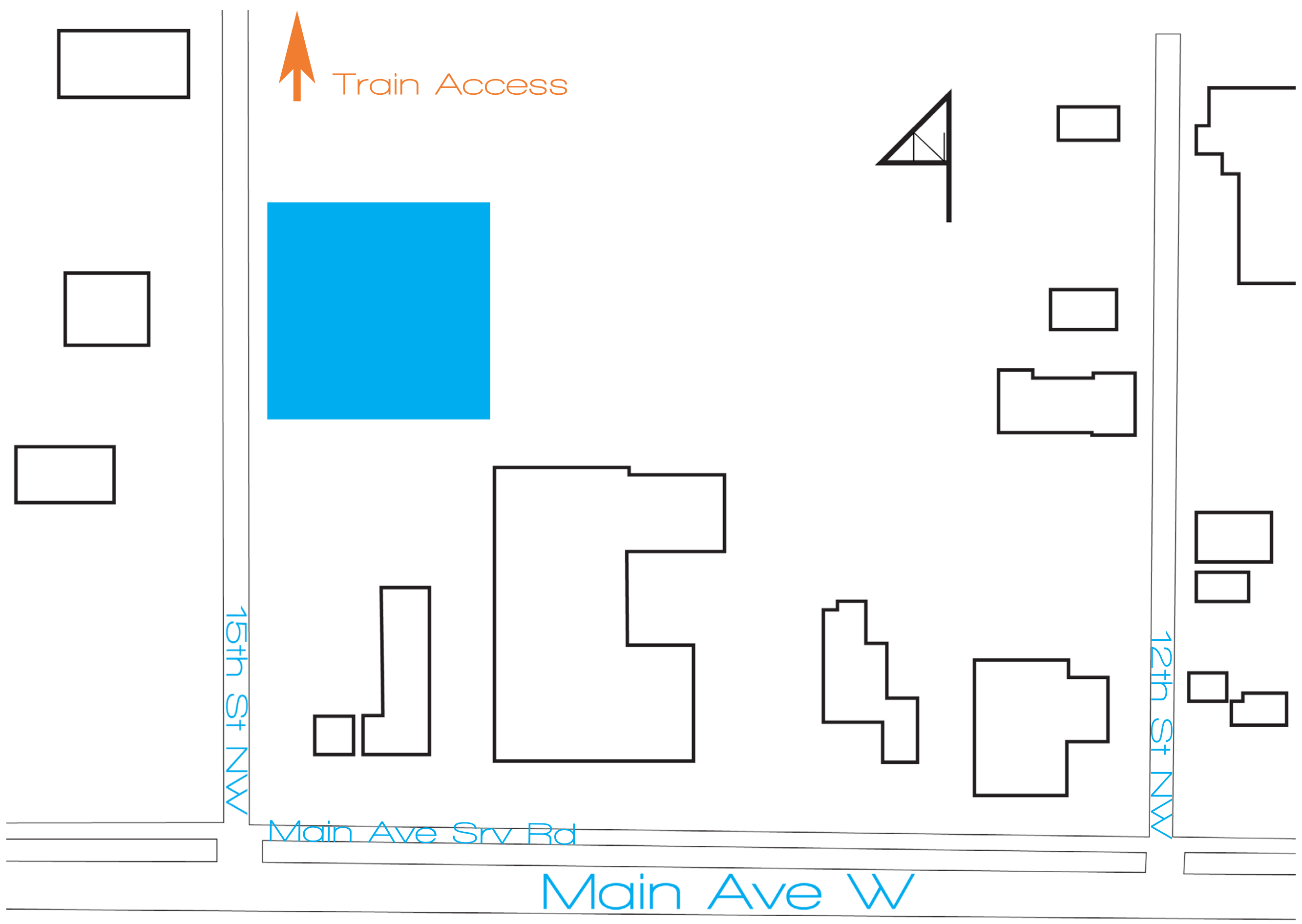


Fig. 2

This particular site is connected to the Caterpillar Reman Drive Train facility and its new Remanufacturing Facility that is currently being built. The site is also very close to a major railroad, highway, and interstate.

Site Views

Fig. 3

Project Emphasis

By using ergonomics and universal design the human interaction with its built surroundings will improve. I am also interested in being environmentally friendly, as well as exploring built environment in its 3D space.

Plan for Proceeding

Definition of a Research Direction

I will research my Unifying Idea, Project Typology, Historical Context, Site Analysis, and Programmatic Requirements.

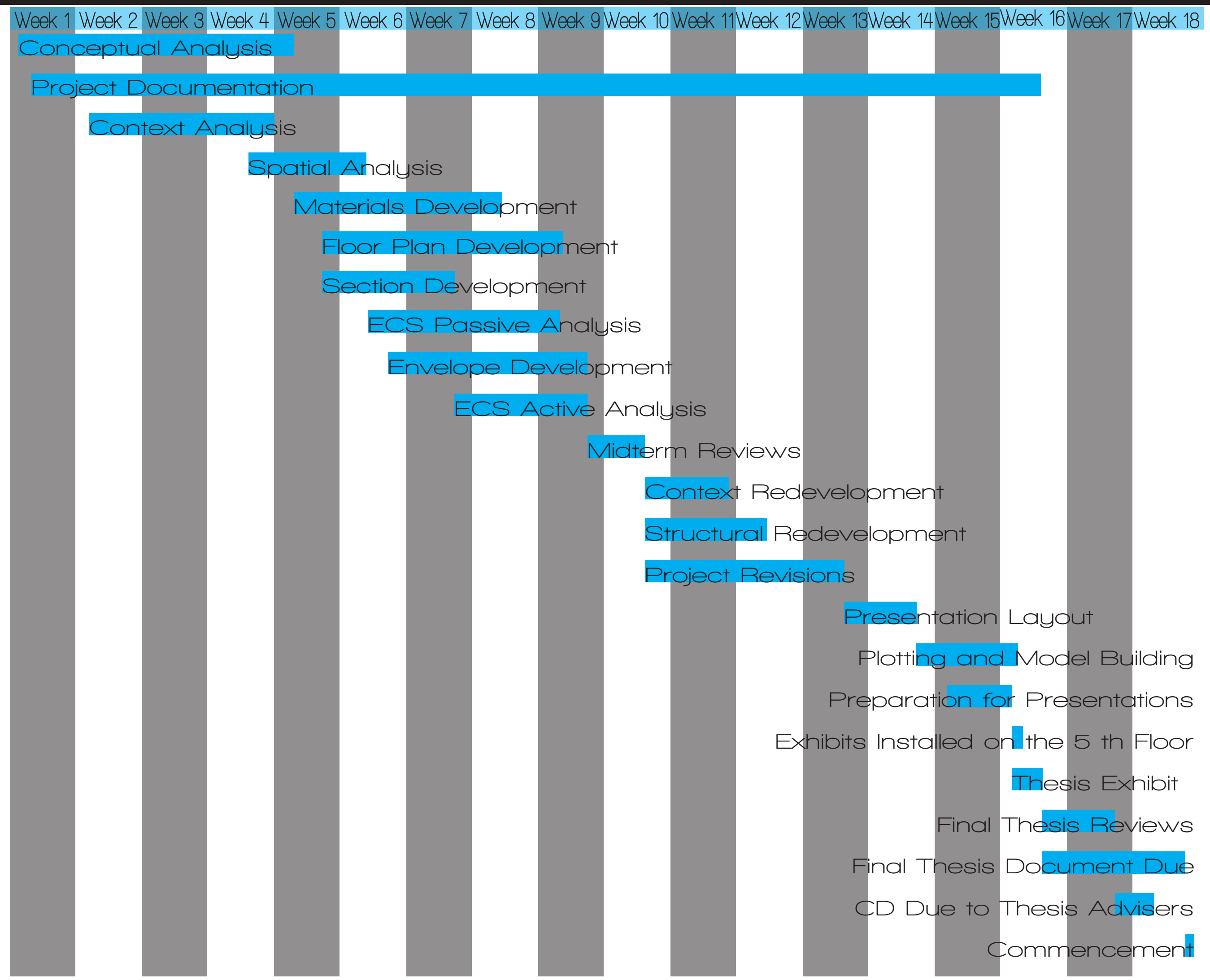
A Plan of Your Design Methodology

The methodology that I will be using to research this thesis is the Concurrent Transformative Strategy. Both the quantitative and qualitative data will be gathered concurrently. My aim is at ergonomics and universal design. Analysis, interpretation, and reporting will be conducted throughout the research process and brought together though both text and graphics.

A Plan for Documenting the Design Process

I will be making models and 3d models. I will be taking pictures of these and documenting them, as well as documenting the site with pictures and drawings. The sketches that I produce will be scanned on a weekly basis and put into a folder, for that week, on my computer and on my external hard drive. At the end of this project there will be a book produced for other scholars to follow. To conclude this thesis I will be producing some boards, a model, and a 3d model that can be walked through with rain, snow, or darkness enveloping the surroundings.

Spring Semester's Design Schedule



Previous Experience

Year	Term	Instructor	Projects
2008	2nd Year Fall	Stephen Wischer	Tea House Boat House
2009	2nd Year Spring	Mike Christenson	Dance Studio Burnt Wood Progression
2009	3rd Year Fall	David Crutchfield	NDSU Branch Library Probstfield Farm Visitors Center Snow Structure
2010	3rd Year Spring	Cindy Urness	Natatorium Biker Bar Bus Rapid Transit Center
2010	4nd Year Fall	Bakr Mourad Aly Ahmed	High-rise KKE Artifact
2011	4nd Year Spring	Malini Srivastava	Design Build Passive House
2011	5rd Year Fall	Malini Srivastava	Design Build Passive House

Project Document

Theoretical Premise
Unifying Idea Research

RESEARCH

This thesis will research the human interaction though the work environment and how the worker experiences those surroundings. My goal is to improve productivity and increase the safety and wellbeing of the dweller. This study will be investigating a research and development facility developing new and improved machinery for other industrial work.

Ergonomics

Ergonomics can be described "as 'the technology of work design' that 'is based on the human biological sciences: anatomy, physiology, and psychology.' In another instance, it is defined more simply as 'an interdisciplinary science which studies the relationships between people and their environments'" (Panero, Zelnik, 1979, p. 12). It is the science that strives "to adapt work or working conditions to suit the worker" (Panero, Zelnik, 1979, p. 12). Ergonomics studies the problems of people adjusting to their environment. It focuses on the human body, its movement, and ways in which to adapt to that particular body.
According to The International Ergonomics Association there are three characteristics of human interaction which are Physical Ergonomics, Cognitive Ergonomics, and Organizational Ergonomics. "Physical Ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity.... Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system.... Organizational ergonomics is concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes" (International Ergonomics Association, 2011).
Everything that we interact with has something to do with ergonomics. How chairs feel to us, how tall your desk is, and the dimensions of a door are all studies of ergonomics. Trying to improve our living conditions is to change our architecture around us to suit the needs of that place. If the space or thing is uncomfortable to us or does not fit our needs then it is failing ergonomically and slows our productivity and may even stop it completely, this could lower morale and be dangerous (if the item is not the right size, is not sturdy enough, ect.) to others.

Universal Design

Universal design is an approach to design that aspires to create environments and objects that can be experienced by as many people as possible. It is a design approach that gives everyone a choice instead of a restriction on the use of

a facility.
Universal Design considers all people in the things we design.

> "**Choice** involves flexibility, and multiple alternative means of use and/or interface.
> **People** includes the full range of people regardless of age, ability, sex, economic status, etc.
> **Things** include spaces, products, information systems and any other things that humans manipulate or create. (universaldesign.com/, 2011)"

"We become better Universal Designers as we learn more about people and the choices they may wish to exercise as they interact with the environments in which they operate. Because of this, no one knows it all. We can all learn from each other about how to better design things for all people. In this lifelong learning sense, we are all students of Universal Design" (Universal Designers and Consultants, 2011).
If more people began to voice their opinions and needs perhaps more spaces would be designed to meet those specific needs. Two main keys that are important in design are listening to your client, and the client voicing their opinion and needs. These are necessary for an environment to become useful to our society. There is still a lot of work and learning that needs to be done in order for this to happen.

Research and Development Facility

A research and development facility needs lab modules, which need to be flexible, safe, and secure. The lab module is an essential element in a research facility, it has to correlate the architectural and engineering systems to be fully utilized. The space needs to be designed for change, "all design decisions should be made on the premise that the function, space, staff, and location will change" (Griffin, 2005, p. xviiii). The lab also may be built based upon later use, depending on where the facility needs to grow. It also needs to be flexible because of the many uses that may need to be studied or worked on. "Many private research companies make physical changes to an average of 25 percent of their labs each year. Academic institutions typically change the layout of 5-10 percent of their labs annually" (Watch, 2008). To ensure that human health and life is crucial, then safety must always be the first concern.
There also may be core labs in the company that will always need and provide services that have a specific machinery that is not easily movable. In these instance these spaces are not as flexible and stay in the same order.
The work space should meet the needs of the staff entirely. As Griffin (2005) stated, scientists have been upset with their work environment complaining it is not fitting

to their needs. It is important in this line of business for them to have an open, flexible work space, and in turn their work will be efficient and at its best. When the environment meets their needs their morale will be higher which provides a higher work ethic.

Design for the computer, meaning that "more and more tasks are undertaken with computers - computer modeling, data acquisition, data analysis and the virtual experiment, all have huge impacts on facility design" (Griffin, 2005, p. xxi).

Because there is a broad range of people from different disciplines working in one facility, it is important for them to interact together. Each discipline has its own voice and each one is important in its own way (Griffin, 2005, p. xxi). Designing for interactions can promote new directions for research by having high traffic nodes, and shared facilities give opportunity for informal meetings. Connectivity enhances the sense of being a part of a scientific community. It allows for an individual to feel involved, a part of something bigger than themselves.

It is important, when designing, to take into consideration that if building a multi-story building the amount of interaction will decrease and perhaps be non-existent, unless there is an open area which everyone can see and has access to. This area may provide the opportunity for those who may not

have had the chance to interact otherwise to do so. This encourages new ideas, new research possibilities, the birth of new friendships, and mixing of different ideologies.

With the large open planned laboratory, the layout benches and equipment should be moveable. This allows the workers to move and upgrade their equipment as needed which allows for maximum productivity. It also provides comfort as the workers have the ability to mold and change their environment to meet their needs.

Piped services like gases, water, and liquid waste plumbing should not be contained by anything that could hinder one from identifying the pipes and the ability to shut off service to one of those pipes, because, in emergencies, valves need to be identified, found, and shut off. Gases in a contained area can create an explosion which could be harmful and dangerous to all people in the building.

Because there is such a large push to be energy efficient, one should be mindful of reducing green house gases to save our atmosphere for future generations. Practicing good sustainable design will ensure that we do not need renovate, waste materials, or even demolish the structure of that building in a few years. Instead, the building should be able to be recycled if it is not needed for that specific purpose anymore.

anymore.
Above all else, safety should be the highest priority in the work environment. Do not rely on the basic safety standards and regulations but assume for all comprehensible ways that the spaces could be used and design accordingly because these spaces that are designed for one purpose may not be used that way forever. One should plan for the worst possible outcome, while having a plan to protect the facility.

3D Manufacturing

Most homes around the world have a printer to print out documents and photos which is essentially a home printing press and photographic lab. What if anyone could plug a 3d manufacturing machine into your computer and printout anything you need right from home? At the University of Bath, Dr. Adrian Bowyer, a engineer and scientist, is the head of the Reprap project. Reprap stands for the Replicating Rapid Prototyper Project. The Reprap project aim "'was to create and give away a machine that makes useful stuff,' explains Adrian Bowyer. 'It enables its owner to easily and cheaply make another for someone else. This is particularly useful where capital investment is low. It makes manufacture similar to agriculture'" (Bowyer, 2011).
The goal of the 3d Printer is to manufacture itself with the help of human interaction. The human in turn gets the opportunity to print whatever he or she desires. The printer has the ability to print parts for itself, as well as other items. It can print about half of its parts and most of the rest of the parts can be bought from a local hardware store. You can design items using your own creativity or go online and download an item and print it from your 3d printer. It is almost like running your own factory next to your printing process and photographic lab.
The Reprap works by melting plastic on a flat plain then moving up and layering the plastic on top of the first layer until you have a 3d object. The filament is a starch base plastic called PLA(Polylactic acid). PLA is a bio-degradable material made from lactic acid that can be produced from plants like corn. So even in the poorest countries it would be extremely beneficial and affordable to build a 3d printer and grow your raw materials and print tools that you would need. Because the product is printed with PLA, a bio-degradable material, if it breaks or there is no further use for it one can bury it in the ground and it will degrade back into the soil and new material can grow from that soil.
In 2008 the first successful reproduction took place when the development team printed a child Reprap from the original. There are

already four evolutions to the project and almost every copy is designed a little different.
They are working on printing new materials and a new print head so that more elaborate items can be made. Some of the designers have already been using the Reprap for other things like; drawing, soldering, and bioengineering. Others have made new printers and have used the sun itself to print on sand.
The system to get products to the consumers is quite complicated and wasteful at this time. Dr. Adrian Bowyer's vision is to have a 3d printer in every home and whenever the consumer wants a product he or she has the ability download it like a song or movie and print out the product without a complicated transportation system, except for the raw materials. In the larger picture this means less factories, less goods to be transported, less waste of energy to use these transportation systems, and less need for money.

Summary

My premises state "Over the last 30 years, physical anthropologists have been concerned with the documentation and description of human body size variability and its application to design. A significant problem continues to exist.... (Panero, Zelnik, 1979, p. 9)" It is apparent that in the past the human scale was not taken into account when the industrial work place began in the United States, better ergonomics would improve life in these areas. Ergonomics applied correctly to its surroundings provides comfort, avoids accidents, reduces stress, and promotes higher functioning levels and overall happier lives.
In my research, I found that my premises are quite true in the world. Certain companies dedicate their time and effort to researching and developing solutions to fit the human dimensions by creating items that we use daily. Items that are well designed are those which we do not notice the design because it feels as if it were always that way. Yet, when we experience an item that does not meet that criteria it is inhibiting and we begin to feel uncomfortable. Although these items make us feel uncomfortable there is rarely any resolution to the problem and it remains unsatisfying.
Many designers and companies like Steelcase Inc., a huge furniture company, spend a lot of time studying how people interact with space and try to develop things to make life better. The problem with this is that we are in a consumer environment. A consumer environment is always pushing new ideas and products, however "new" does not always mean "better". In fact, many products today are not made with the same care they used to be and quickly fall apart. With the production of the new product, we have no use for the old, so we dispose of the old causing more waste. If it is broken, instead of fixing it, society tells us to get a new one. This is where the idea of PLA in the 3d manufacturing comes into play. This allows for a broken item to easily be fixed and restored which it turn saves the consumer money and is eco-friendly. Recycling the product safely which does not have a purpose is also possible through this method. The product is returned to the earth and biodegrades.

My unifying idea is that architecture should be the study of ergonomics, the built environment for the human scale, which should improve human needs. An environment that is consistent with our needs.
Ergonomics is the study of humans and the space around them, and architecture is that space in the built environment. Architecture should always form to the human and his or her needs and not to any other element; otherwise it could be very uncomfortable for us.

Typological Research

Max Planck Institute for Plasma Physics, Greifswald Branch

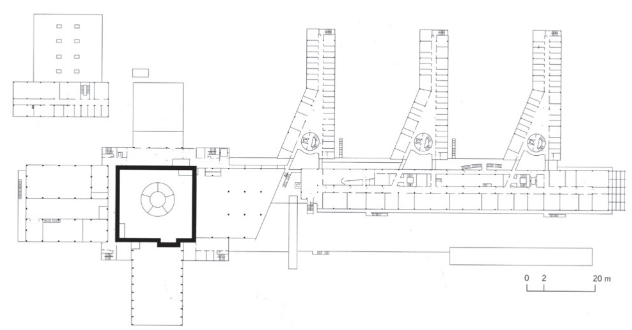
Project type
Research and Technology Institute

Location
Greifswald, Germany

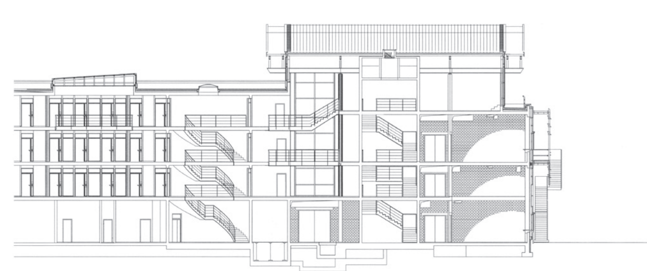
Size
8,800 sq. m.

Distinguishing Characteristics
Superimposed wavy roof
Three institute sections
2 meters thick concrete box structure

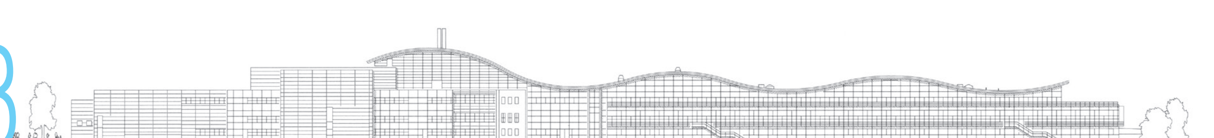
Existing Program Elements
Laboratories
Testing Facility
Offices
Central Access Spine
Entrance Hall
Library
Cafeteria
Seminar Rooms
Workshops
Computer Pool
Courtyards



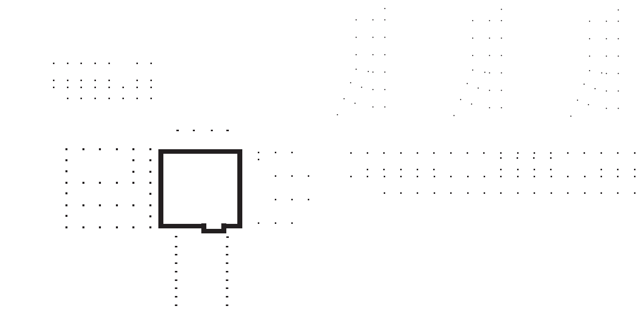
Plan Fig. 1.0



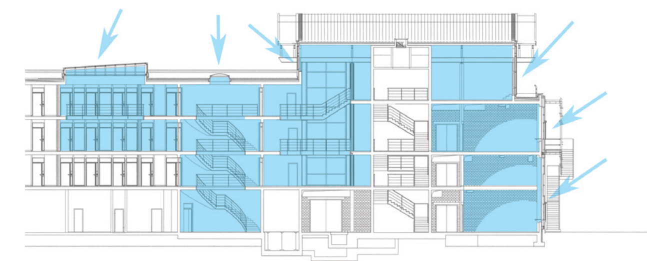
Section Fig. 1.1



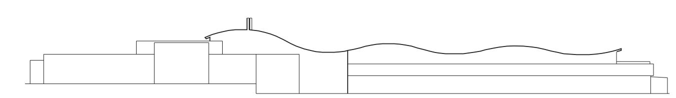
South Elevation Fig. 1.2



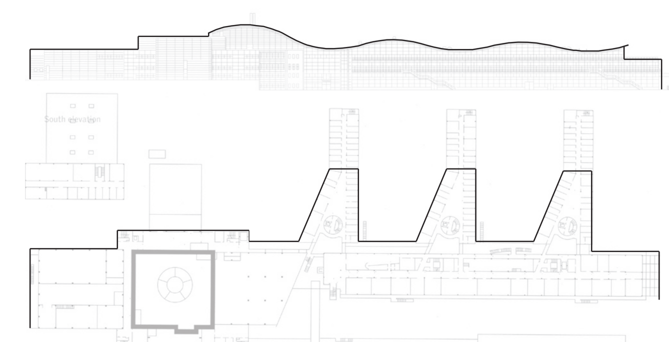
Structure Fig. 4



Natural Light Fig. 1.1



Massing Fig. 1.2

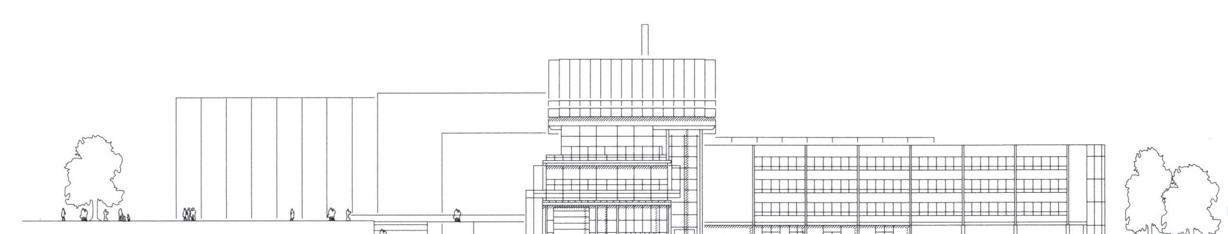


Plan to Elevation Fig. 1.0 & 1.2

This facility established the plasma physical fundamentals of a fusion power station, it strives to generate energy out of nuclear fusion like the sun. For this facility to function it requires cooperation from scientists, engineers, and multiple technical staff. The building was set up in such a way so that the multidisciplinary cooperation could be utilized efficiently. The layout is set up to have the distance and orientation between offices and testing facilities. This circulation space design is to generate ideas and communications between these multiple disciplines, as well as link the entrance, library, cafe, and offices. The experimental equipment requires so much energy that the local power supply is not enough so they had a special 110 kV line installed from a national power supplier.

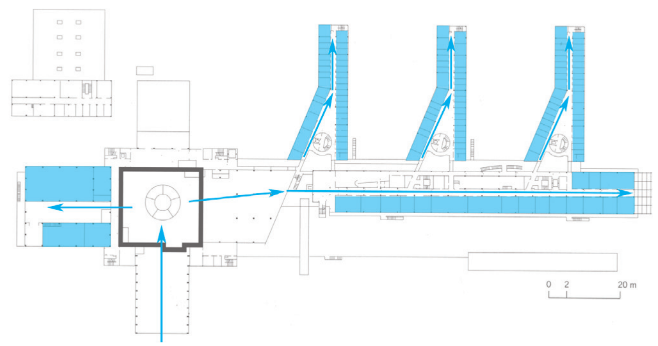
Common and Uncommon

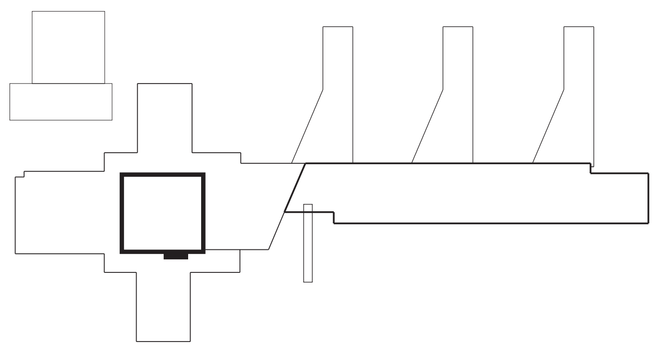
This facility has a main large laboratory, but, unlike the others, this one is not an open planed hall and it holds one big nuclear fusion experimental piece of equipment called WENDELSTEIN 7-X. It has many offices like the rest and workshops. This is a small university and with that it houses its own cafe and library which the other

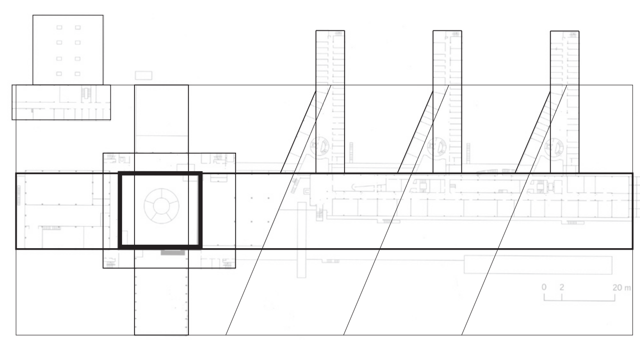


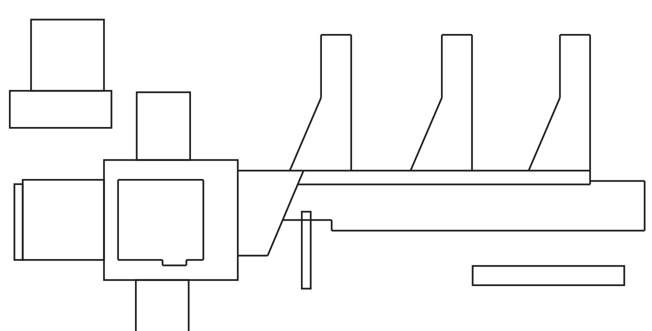
North - East Elevation Fig. 1.3

two do not. Also, at 8,800 square meters, which is about 28,871 square feet, it is the biggest research facility out of the three. Total encase volume is 245,500 cubed meters.


Circulation to Space Fig. 1.0


Hierarchy Fig. 5


Geometry Fig. 1.0


Additive and Subtraction Fig. 6

Panta Rhei Research Centre for Lightweight Materials

Project type
Research and Technology Institute

Location
Cottbus, Germany

Size
4,000 sq. m.

Distinguishing Characteristics
Curved steel girders that from the hall

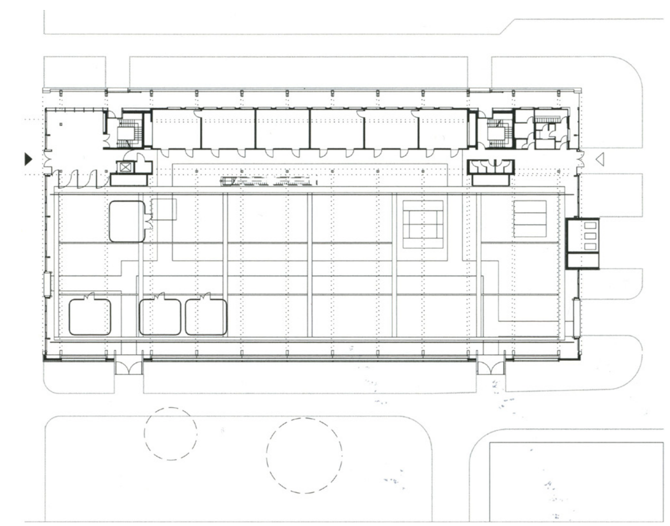
Red hallway that protrudes out of the building

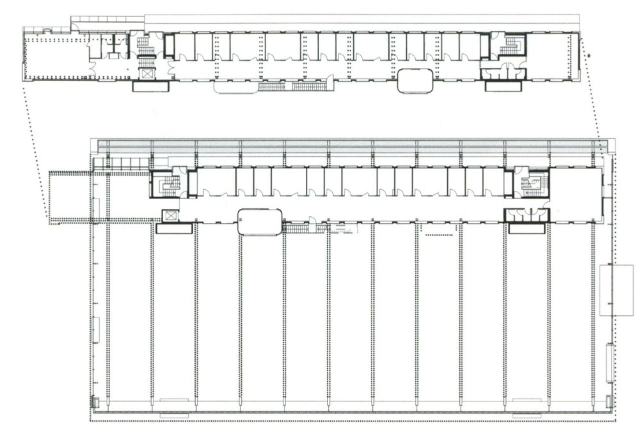
Existing Program Elements
Laboratory Hall

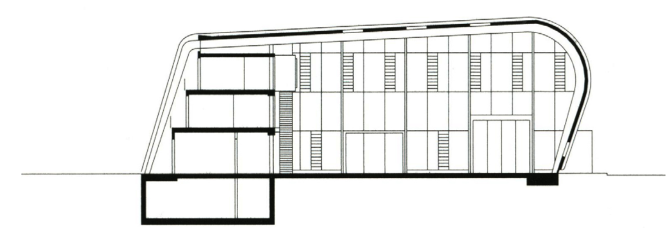
Laboratories

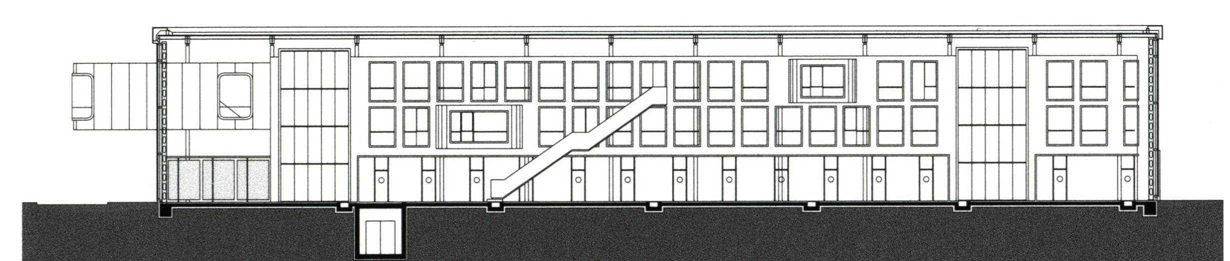
Mixed-Use Offices

Meeting Rooms


Ground Floor Plan Fig. 2.1


Second Floor Plan Fig. 2.2

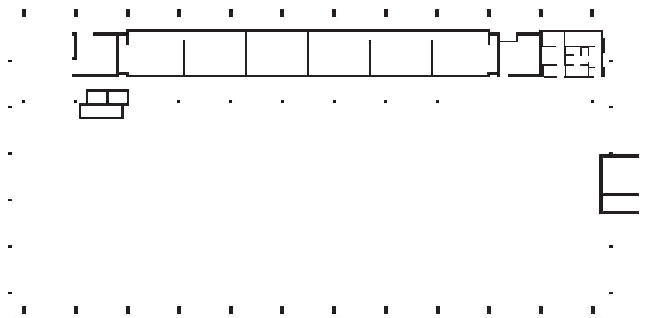

Section Fig. 2.4


Elevation Fig. 2.3

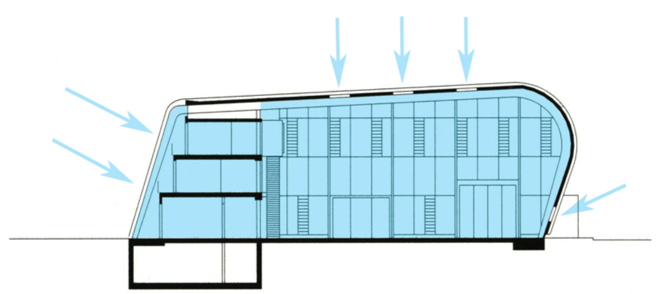
This facility is run by the Mechanical Engineering and Electronics Department at Cottbus University. Their primary research is in the field of lightweight materials for the automotive and aviation industries. The university has strived to combine teaching with hands on and work experience, and through multi-disciplines the architecture program set up a nonprofit company to refurbish and extend projects; this building was one of their projects. The Mechanical Engineering and Electronics Department are doing the same things by linking industry with the university and merging theory and practice.
The goal of the main hall is to have a open large space with open arrangement as to be flexible for the future and a variety of projects. There is an entrance connected to a corridor that connects the main hall to three levels that houses offices, mix-use rooms, and laboratories.

Common and Uncommon

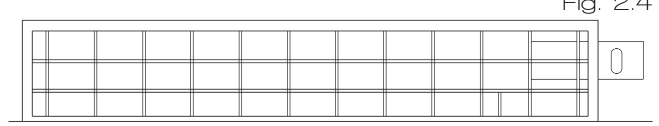
This facility also has many offices, a large open planed laboratory hall, and is owned by an university. The building was designed by students from the university and looks the most alive with its clean steel girders that bend and the crisp red and yellow colors brought into this building making it the most contemporary of the three. This is the only building that incorporates the offices into the main building, the other two push the offices away, as if to different entities. It was built in 2002 also making it the youngest out of the three. This is the smallest of the three at 4,000 square meters, which is about 13,123 square feet, total encase volume is 41,000 cubed meters.



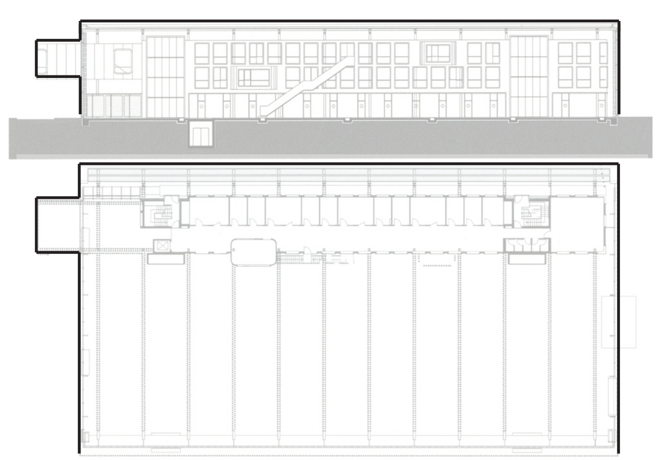
Stucture Fig. 7



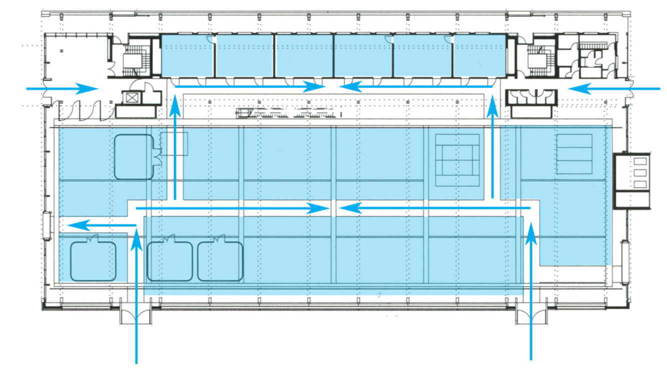
Natural Light Fig. 2.4



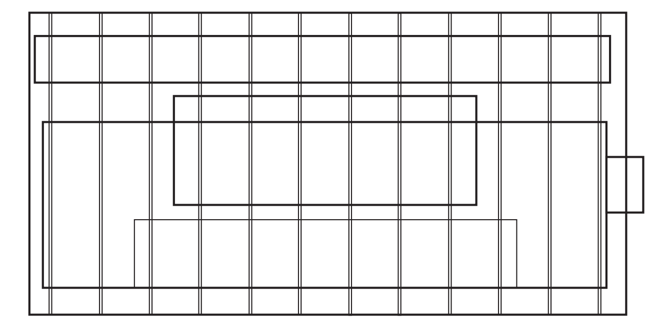
Massing Fig. 8



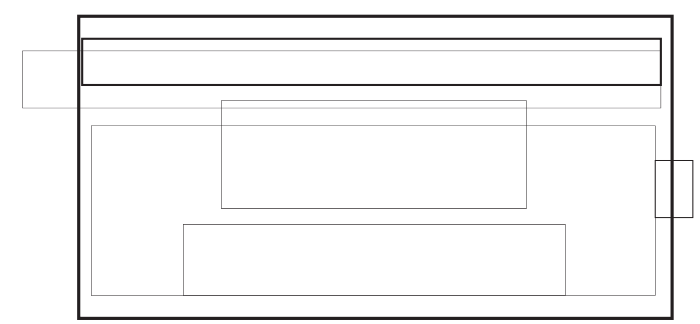
Plan to Elevation Fig. 2.2



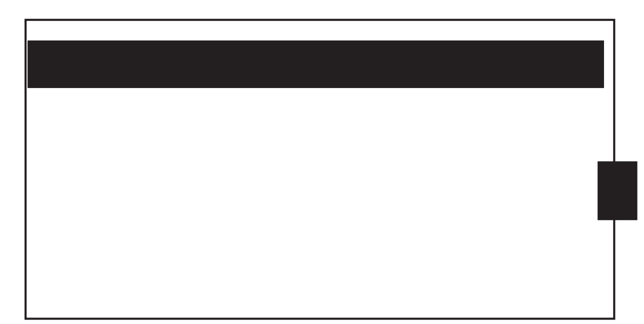
Circulation to Space Fig. 2.1



Geometry Fig. 9



Hierarchy Fig. 10



Additive and Subtractive Fig. 11

Physics and Astronomy Laboratories, Leiden University

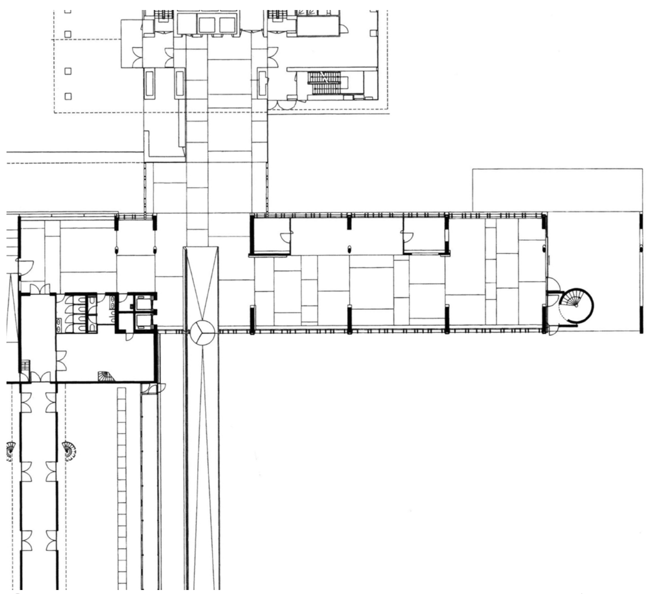
Project type
Office and Laboratory Institute

Location
Leiden, Netherlands

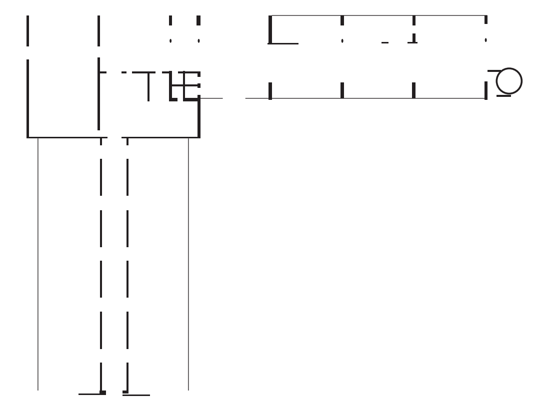
Size
6,700 sq. m.

Distinguishing Characteristics
Building is leaning at a ten degrees angle

Existing Program Elements
Laboratory Hall
Five Office Floors
Traditional Central Corridor
Storage
Workspaces



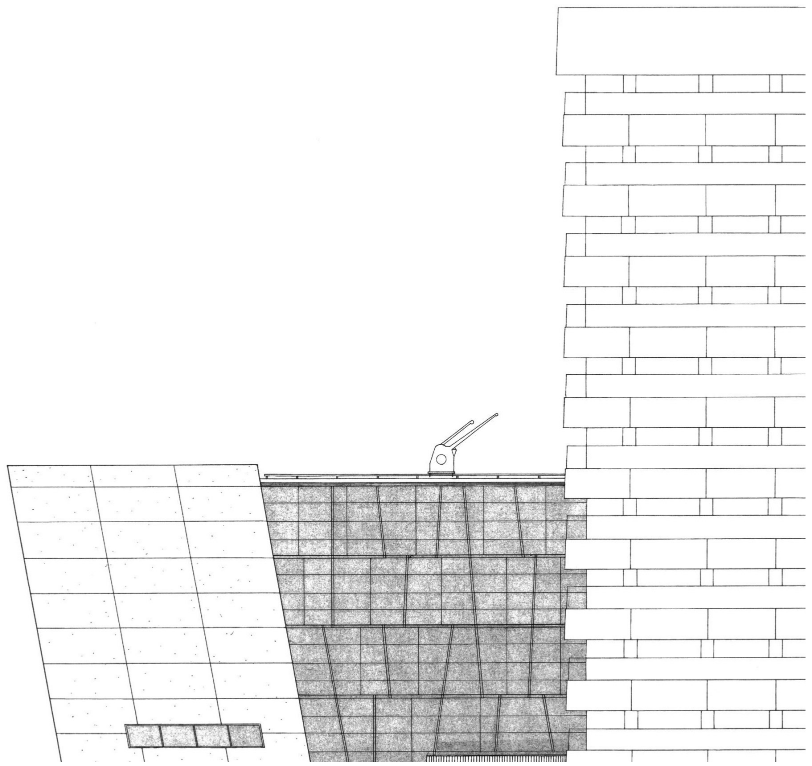
Ground Floor Plan Fig. 3.1



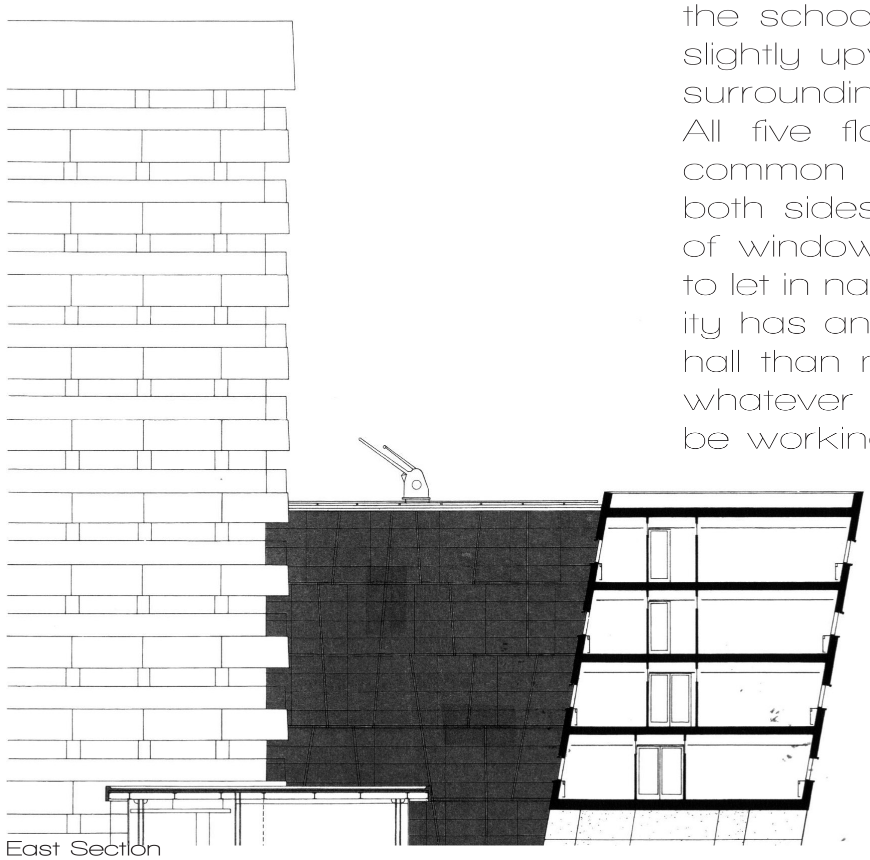
Stucture Fig. 12

Leiden University's character is found through their sixties to seventies architecture. This laboratory and office building is an expressive building that imposes its presence as an ambitious place of science. There are three architectural parts to this building: five inclined leaning office floors, a translucent glazed ground floor, and pushed under all of this is a large laboratory hall which is all linked to the neighboring laboratory with footbridges. The main floor, which holds the entrance to the building and their auditorium, is mostly glazed which brings in much natural light and a warm feeling to the overall building. The five floors of offices lean forward toward visitors and stick out with this adventurous diversity making this a landmark for the school. The laboratory curves slightly upward and blends into its surroundings.

All five floors of offices have a common corridor with offices on both sides, and they have a strip of windows just before the ceiling to let in natural light. Again this facility has an open planed laboratory hall than makes it very flexible for whatever project the students will be working on. Because the labo-



West Elevation Fig. 3.3

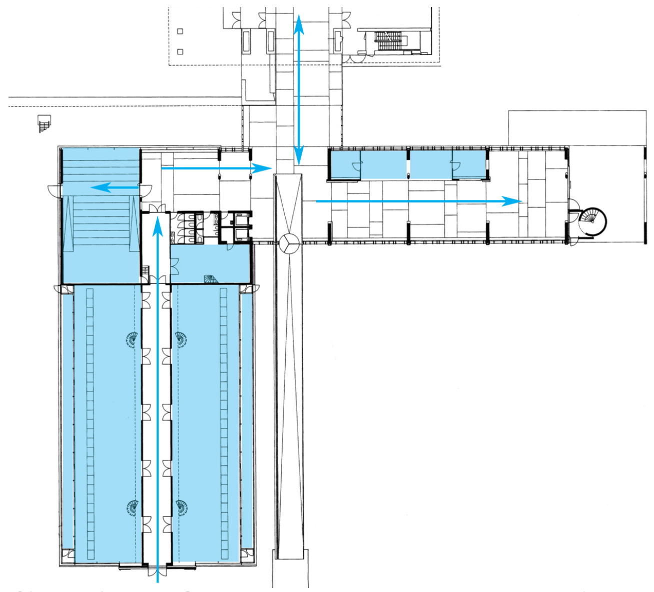


East Section Fig. 3.2

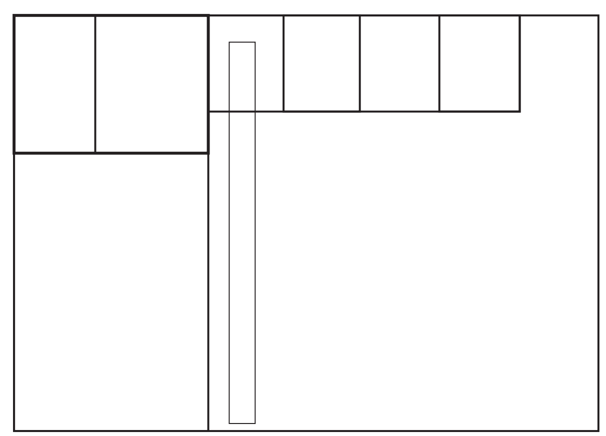
ratory is somewhat underground, it utilizes the space under the main corridor for storage and utilities like water, electro, and gas supply. The main floor houses the students main workstations and computer room but overlooks the laboratory hall so that they always have a visual connection with the continuing experiments.

Common and Uncommon

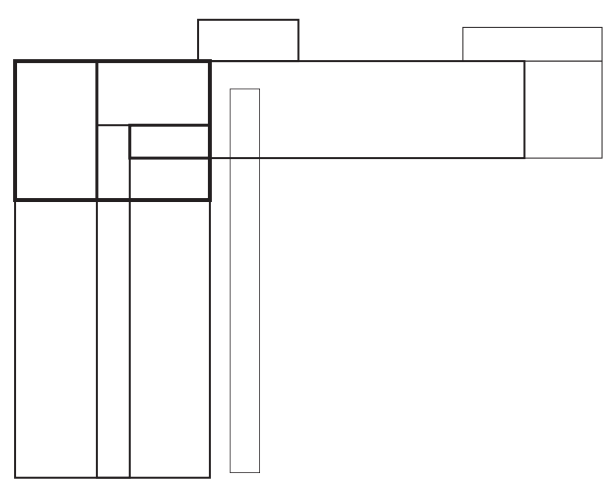
The other two facilities are in Germany and this one is in the Netherlands. This one also has many offices, a large open planed laboratory hall, and is owned by an university. The office has a certain uneasy feel to it. The atmosphere is overbearing as if to keep the workers on their toes, ensuring they will get all their work done. The offices also have an outside fire escape which is unique to this building, and is the only building that is connected to another building. This building's dimensions fall between those of the other two buildings presented with an area of 6,700 square meters which is about 21,982 square feet.



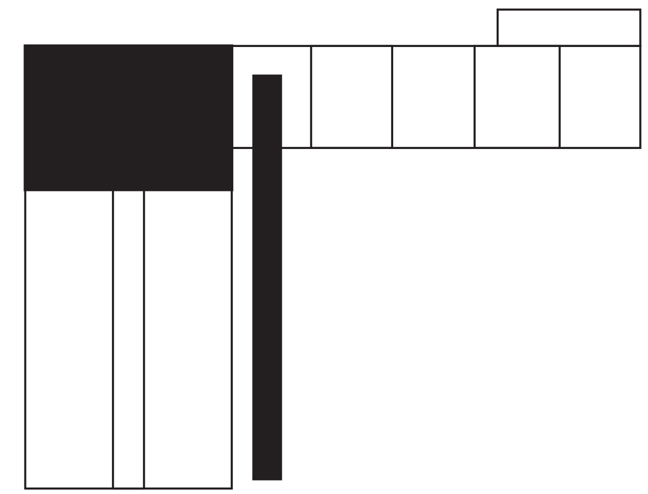
Circulation to Space Fig. 3.1



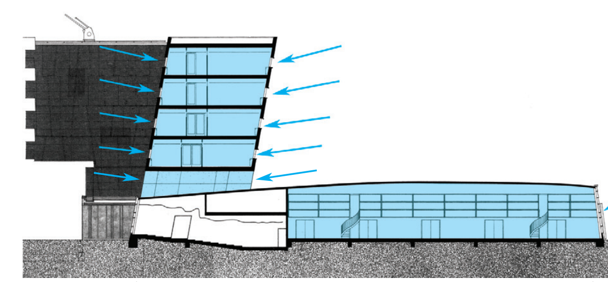
Geometry Fig. 13



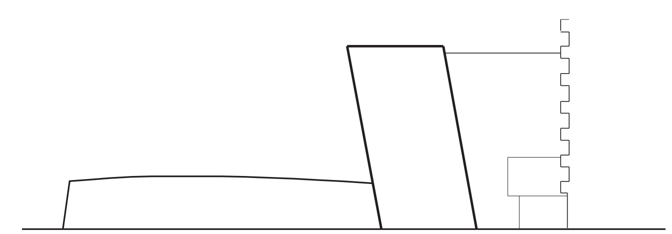
Hierarchy Fig. 14



Additive and Subtractive Fig. 15



Natural Light Fig. 3.2



Massing Fig. 16

Summary

Max Planck Institute for Plasma Physics, Panta Rhei Research Centre for Lightweight Materials, and Physics and Astronomy Laboratories are research and technology buildings developed for universities in the European Union.
Max Planck Institute for Plasma Physics has a bulky, cubed main form and flowing from it is the main corridor that connects the facility together; three mixed use laboratories and office complexes root out of the corridor hall. This building mainly researches nuclear fusion and is built specifically around one piece of equipment.
The building program had some issues, which the designer had some good design solutions for. With multiple floors and strict zoning in the building they still were able to bring people together in the main lobby and corridor hall that most of the sections of the building funneled into.
Panta Rhei Research Centre for Lightweight Materials is the most contemporary building and was designed by students from the university. Its elegant curved form and red corridor, that punches out of the main body, give it a distinctive look. It has a main large laboratory hall and three stories of offices that overlook the experiments that are going on. The design floods the building interior with natural light

through the three-sided glass, so even with so much steel and aluminum facade it still has a warm and inviting feel. It is the only building that houses all of its program under one roof. This facility brings students into the research and development of lightweight materials for automotive and aviation industries.

This research center is propelled by communication and teamwork and shows that research facilities can benefit from cutting edge architecture. Even though the offices and work spaces are on the second and third floors, the hallways and stairs connect people to the grand hall. This building has the most uniformed building layout.

The Physics and Astronomy Laboratory sticks out from its monotone surroundings, not with color or an outrageous form but from a slight lean of the main office building and a slight curve from the laboratories. This university building is connected to an older laboratory and also has windows surrounding the large laboratory hall. The workspace for the students overlooks work being done in the hall and the offices tower over the hall in an eerie way. I feel that this building has the biggest disconnect. The offices and laboratory staff never see each other, helping this fact is that there basically two buildings with one on top of the other. The space they

it the entrance, but, unlike the others, the offices look out to the campus and not the laboratory hall. A defining characteristic is the office fire escape, and even that does not include the hall. All the offices do is lean over the hall like they oversee others' activities.

Historical Context

North Dakota

North Dakota was explored by French Canadians in 1738 and was owned by the French until 1803, when the United States bought most of the territory in what is know as the Louisiana Purchase. In 1812 Scottish and Irish people were first to settle in North Dakota in a city called Pembina. The United States settled their dispute with Great Britain in 1818 and acquired the north east part of North Dakota. Most of North Dakota was uninhabited until the 1870s, when the railroad was built in the region. North Dakota became a official state of the United States in 1889. The first industrial plant developed in West Fargo was the Equity Cooperative Packing Company in 1917. That plant and the housing north of the highway was bought out by Armour and Company in 1925, and the workers moved south of the highway. The industry grew rapidly in this area. West Fargo became a city in 1947 and continued to grow in many industries including: large farm distribution center, large feed mills, meat processing, pelleting plant, manufacturers, retail, and distribution plants. The city turned into two cities in 1967, the north became West Fargo Industrial Park and the south part becoming the City of West Fargo. They formed back into one city in 1974 to just City of West Fargo.
Manufacturing industries have been growing steadily, especially in food processing and farm equipment. The state has plenty of coal and oil reserves, and it also produces natural gas, lignite, clay, sand, and gravel.

History of Steel

The first steel items have been seen since the 4th century BC. The Iberian Peninsula started the use of steel as weapons and the Roman military made their weapons from Noricum steel. The Chinese started to melt wrought iron together with cast iron to form semi carbon steel, and in East Africa developed furnaces that could forge together carbon steel. In the 9th century, in Merv, crucible steel was achieved by slow heating and cooling of pure iron and carbon.
In the early 20th century there was a great rise in the demand for steel buildings, and it still is a very popular choice for residential and commercial projects. During World War II many steel structures were built for the military, and, after the war, they became dwellings. With a vast supply of this alloy many more structures were built, and with that knowledge grew of the durability and strength of the material, so more diverse buildings were built. The first prefabricated buildings were introduced in the 1960s. The metal components were all premade including the frame, roof, floor, and walls. This made the construction process faster and easier, and ultimately made the

industry more dynamic. With the computer involved in the 1960's steel buildings got more features, sizes, and design.
Now there is a variety of steel types of buildings including; Arch Steel, Clear span, and Straight walled buildings. Arch Steel buildings span up and around to the other side of the building and are structurally very strong. Clear span buildings have large girders across the space with beams to hold it up. Straight walled buildings are not as sturdy but have a good amount of space inside. Clear span has the largest amount of interior space which is used in commercial and industrial projects. Because the beams can be designed in different places around the building, it is an ideal choice for an easily rearrangeable floor plan.

Paddington Station

One of the first steel buildings was the Paddington Station, built in 1838 at London. The roof is supported by wrought iron arches, they have three different spans 68 feet, 102 feet, and 70 feet. The roof spanned 699 feet long and was mostly glazed. This new innovation material was the new architectural and engineering sprit, it was light weight, economical and expressed a much more simplified form.

Fig. 4.1

Crystal Palace

Prince Albert, the head of the Society of Arts in London, wanted to impress the world with the industrial achievements Great Britain had fostered. The exhibits that they were going to display were raw materials, machinery, manufacturers and fine arts. Sir Joseph Paxton was the designer and learned from making a cast iron green house that its strength, durability, simplicity of construction, and speed could make a building span an area that has never been built before. The Great Exhibition completed construction in October 1851, the building was enormous at 1,848 feet long and 408 feet wide and 128 feet tall, totaling a 990,000 square feet volume. It was so massive that full sized elm trees fit inside the new steel structure.
At the time, this was one of the largest spanning and enveloping buildings of its era which was made possible due to the advancements of steel. Steel was still to be advanced in later years.

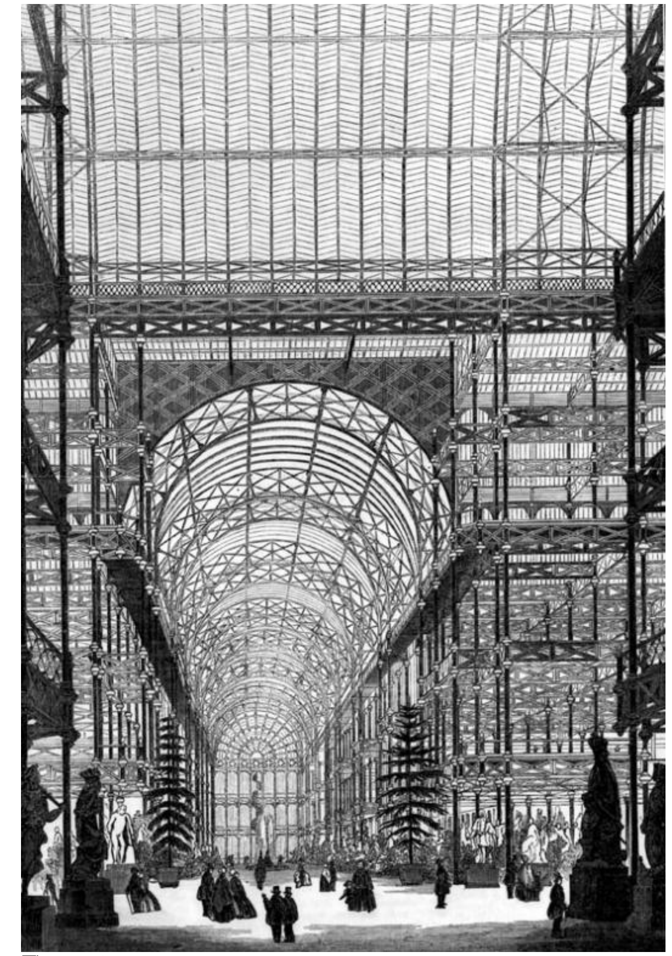


Fig. 4.2

St. Pancras Station

Fig. 4.3

The latter half of the nineteenth century saw even larger spanning buildings. The St. Pancras Train Station designer William Henry Barlow drew out the structure to have a single-span elliptical overall roof that spanned 243 feet. At that time it was the largest structure in the world. Again, the material was wrought-iron in the framework and glass covering the middle to allow for natural light, and the outer edge of the roof was covered in wood. It was 679 feet long, 236 feet wide, and 98 feet high from the train tracks. The outer walls were brick, and the project finished in 1868.

Galerie des Machines

Fig. 4.4

The Galerie des Machines was designed for the Paris International Exhibition in 1889. The architect was Ferdinand Dutert, and the building was well known for its broad exhibition hall, also made posible from the three-pin arch. It was built from iron and glass and it spanned 374 feet across. With these innovated three pinned arch introduce structural steel to massive proportions that have not been matched. From here to the twentieth century brings steel from land to air with the crafting of structural steel so thin that we can develop the air plane. Still today we are always trying to achieve greater spans to house larger things.

History of Industrial Buildings

Industrial buildings started to develop with the invention of large machines. In 1784, James Watt constructed the first steam engine. Inventions like the steam engine and the growing population made it possible for industrial building to form. With the population moving from farms to city, demand for goods and capital increasing drove the need for more things to be made at a faster rate. The cotton industry in England was expanding so fast that they were the first to start using the mechanized mill.

Workshops then expanded into mills, and mills, in turn, expanded into factories.
From this point on rose a new social class of the modern worker which developed into a working class neighborhood by developing industrial cities. Smelting iron began in England and large buildings to house this equipment starting to emerge. From 1775 to 1779 the first iron bridge was constructed and all the iron produced came from a smelting industrial facility. In the early eighteen hundreds it was starting to seem that this iron casting would be the architecture of the future, this is because the traditional building materials at the time could surpass iron in pressure and shear but not in tension.
The use of iron to span large distances for bridges inspired the idea to use these iron bridge building techniques to accomplish larger areas of space within one building. With these large industrial buildings being developed the ability to produce glass in larger sheets was made possible. This change allowed more industries to grow and prosper.

Thesis Project Goals

Academic Goals

One of my goals is to stay organized and to keep on track with my timeline for this thesis project. I do not have the time, nor the luxury, to procrastinate. This project is the most important of my academic career, and will be the highlight of my portfolio. This is also important for my future career, as it could make or break me getting hired at a certain Architecture firm. I strive to always do my best in everything I do and to impress my teachers, as well as my colleagues, in all my academic endeavors. I will be using my 3d printer in combination with the 3ds Max and the Unreal Development kit to develop my project with the hopes of boosting my portfolio, as well as receiving a good grade. My ultimate goal and most proud moment will be when I graduate with a Master's Degree in Architecture. My hope is that this project enhances my communication skills. I also am optimistic that this will open doors for me and get my name out in the Architectural Industry.

Professional Goals

My main goal is for this project to receive employment from an Architecture Firm after graduation. After receiving employment I want to work toward receiving my accreditation as a full licensed architect. In the years to follow, another goal is to create my own Design Company. I will set my own hours of operation at my Design Company as well as provide reasonable work hours for my employees so that they, too, have quality time to spend with their families.

Personal Goals

My main goal is to live life fully and enjoy every moment of it. I want to be able to have a healthy balance between time spent at work and leisure time with my family. I want to provide for my family and be financially stable. I want to settle down with my wife and own a home where we grow old together. I want to travel the world with my wife, seeing new and exciting things that inspire me. I want to begin having children with my wife very soon. My goal in life is to succeed in everything I do, always giving one hundred percent. I want to grow from this project and use it to my benefit. Respect from others is also something I hope to gain out of this project. I want to be respected as a husband, student, and future architect. I expect that others will take my ideas seriously and consider me an essential part of their team. I have a lot to offer, and I am excited for my future and when I get to share my ideas and become a part of something bigger.

Site Analysis

Clear to Cloudy Days

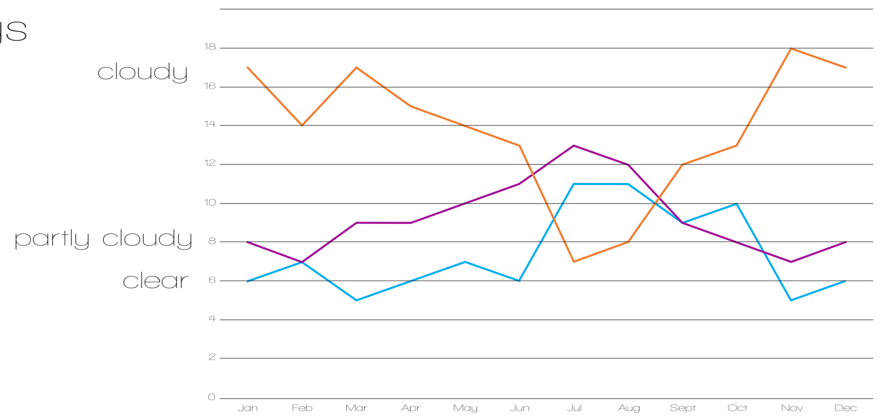


Fig. 17

Average Temperature
in Fahrenheit

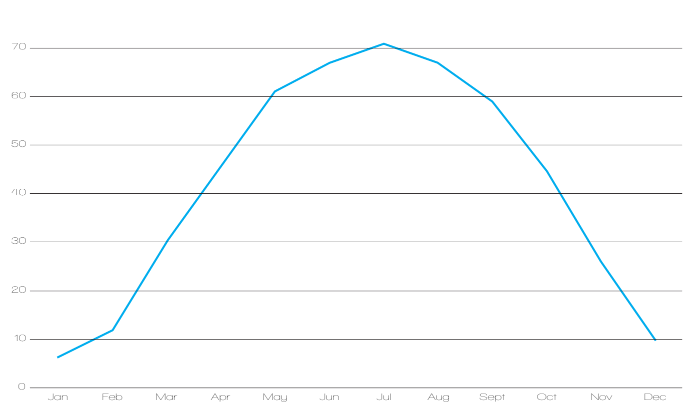


Fig. 18

Average Precipitation
in Feet

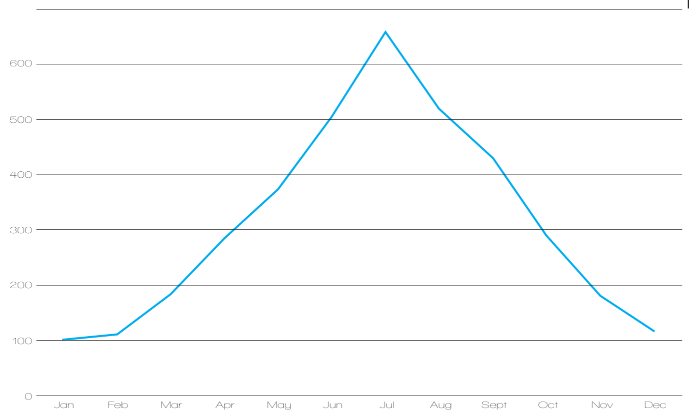


Fig. 19

Relative Humidity
in Percentage

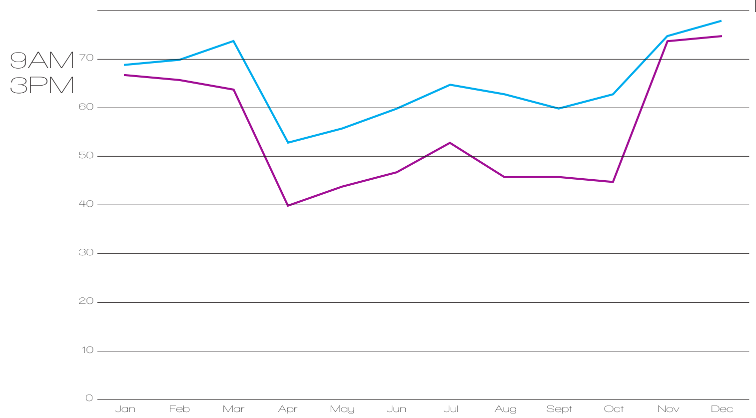


Fig. 20

Sun Path

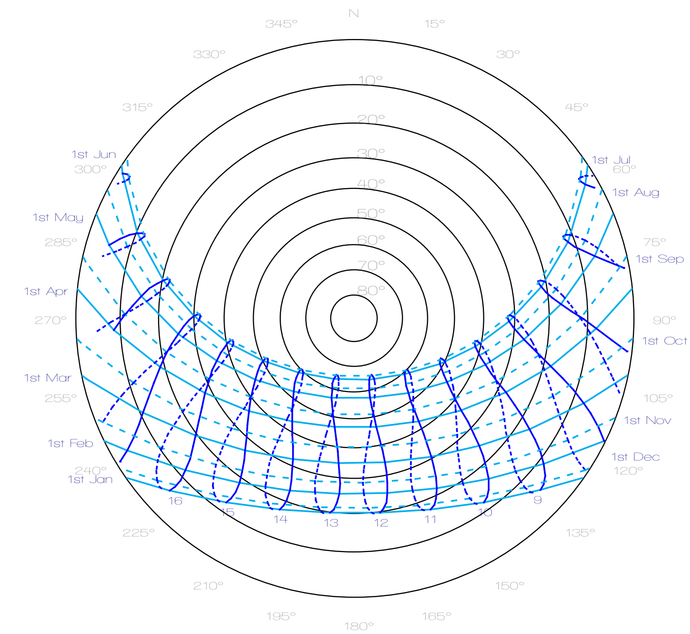


Fig. 21

Wind
Speed and Direction

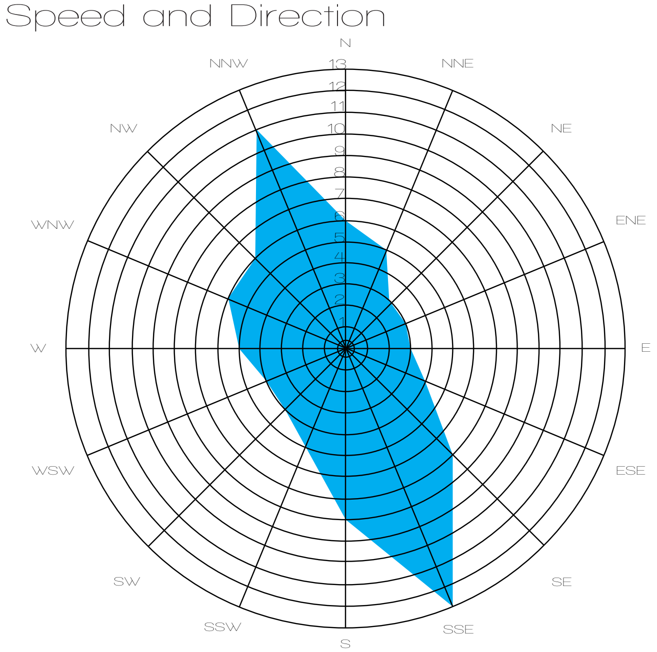


Fig. 22

On my first glance of the site I felt as though it was rather desolate. There were very few buildings and it was very calm. The only car that drove by was a communication's car which gave me the impression that it was a fairly quiet area. There are no plants, trees, or shrubbery around. The only green I saw were unwelcomed weeds. The site is very windy as there are no trees in sight. It is very monotone, there is not much color or vibrancy, as it is all industrial buildings. North of the site there are train tracks and farm fields, while east and west of the site there are the industrial buildings, and in the south, past the highway, is the beginning of residential buildings.

The only activity that was seen was that of the Caterpillar employees building their new expansion site. The existing grids are basically roads and the railroad track. The only shade that was present came from the one story buildings surrounding the site. The geometric relationship between buildings was that everything was square. The topography of the site was fairly flat; it almost changes by a foot from corner to corner. There was no visible water present at this time; however, during flooding season this may change. The wind came from the northeast and it appeared that nothing would affect the wind's flow.

The site appears to have been

tilled at one point in time for next year's crop planting. There were people present at that time who were building the recycling facility for Caterpillar. The site is very barren; there is little vegetation, no water, no trees, and not much to look at.

There are power lines by the site that were visible. There are many occupied buildings around this site which suggests that there are sewer and water lines which are out of sight.

There is some vehicular traffic on Main Avenue but not much on the service roads. There is no pedestrian traffic, as there are no sidewalks. My slope analysis showed that the site will not drain very well because there is not much slope. There is no terrain on this site as everything is flat.

In conclusion, I will have to be cautious of snow pile up, be careful as there will be direct wind on the site, and, since the site is flat, I will have to plan accordingly for water drainage off the site.

Shading, Noise, and Air Movement

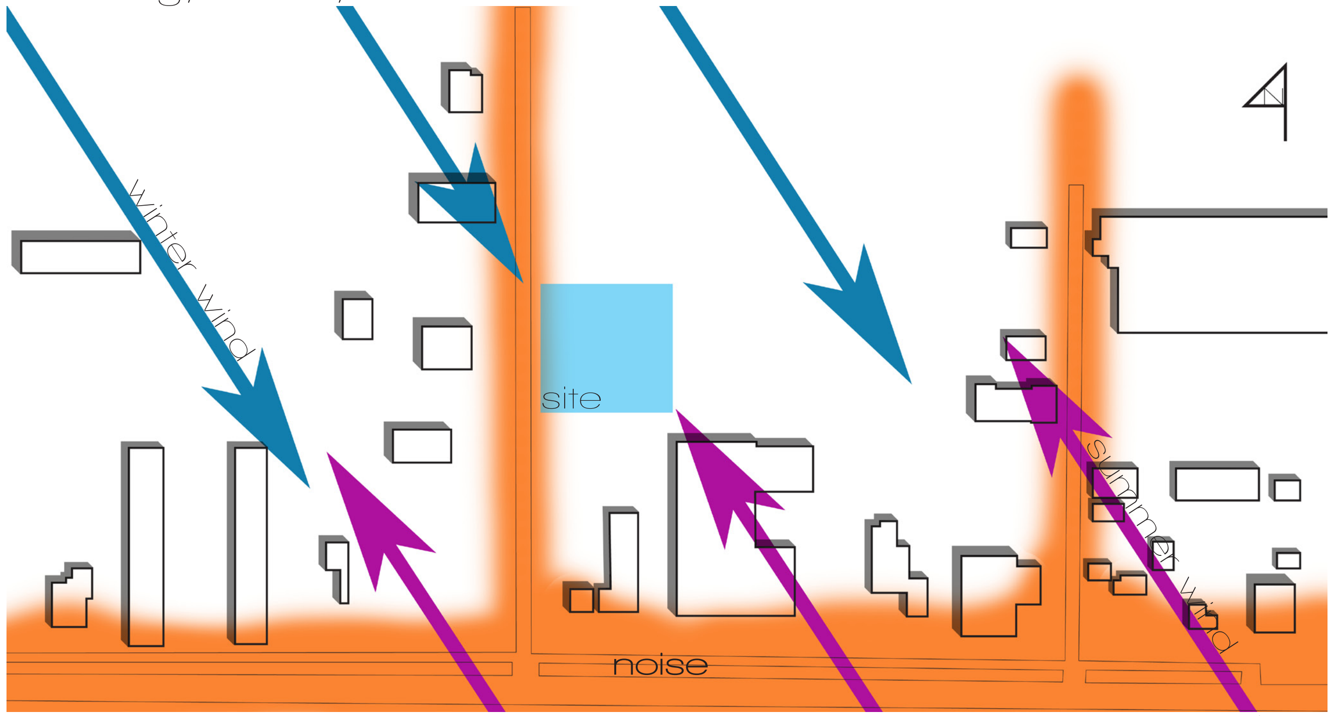


Fig. 23

Topography and Slope

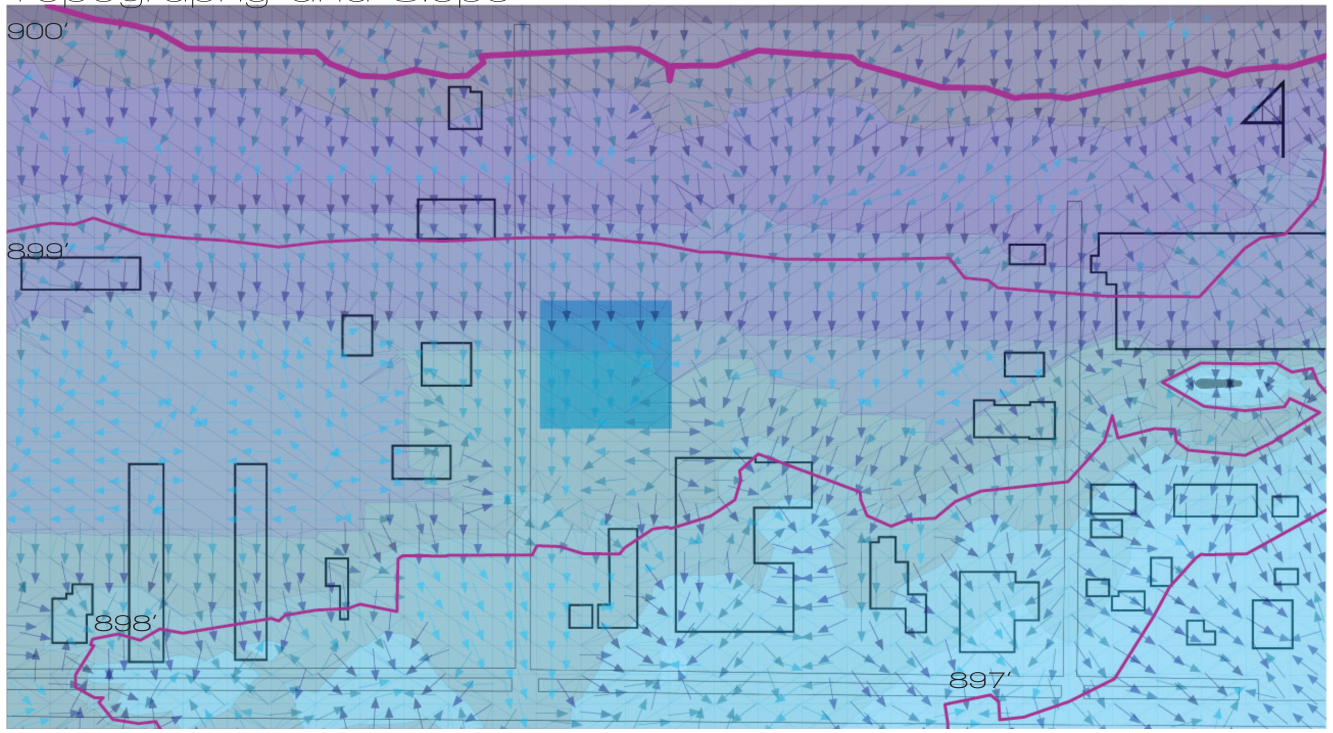


Fig. 24

Programmatic Requirements

Entry The lobby, the juncture of the whole facility	500 sq. ft.
Administration/Staff Offices Offices that serve as a base for the full-time researchers	1000 sq. ft.
Conference Room Conference Room is a meeting space for the gathering of the workers at the site	400 sq. ft.
Bath Rooms	200 sq. ft.
Staff Breakout Relaxing space for the researchers	400 sq. ft.
Reference Library Library space includes a broad range of books and journals with topics pertaining to the research undergone at the facility	500 sq. ft.
Open Planned Laboratory Large open space with moveable modularized work spaces, benches, and services	8,000 sq. ft.
Bulk Storage Storage space for all miscellaneous parts and raw materials for R&D	1000 sq. ft.
Noisy Equipment Somewhat sound proofed room with cacophonous equipment	1000 sq. ft.
Outdoor Testing Space An enclosed space for analyzing and testing the concept artifact	-
Hazardous Materials Storage A storage space for gases and chemicals	750 sq. ft.
Loading Dock	250 sq. ft.
Overall	14,000 sq. ft.

Interaction Net

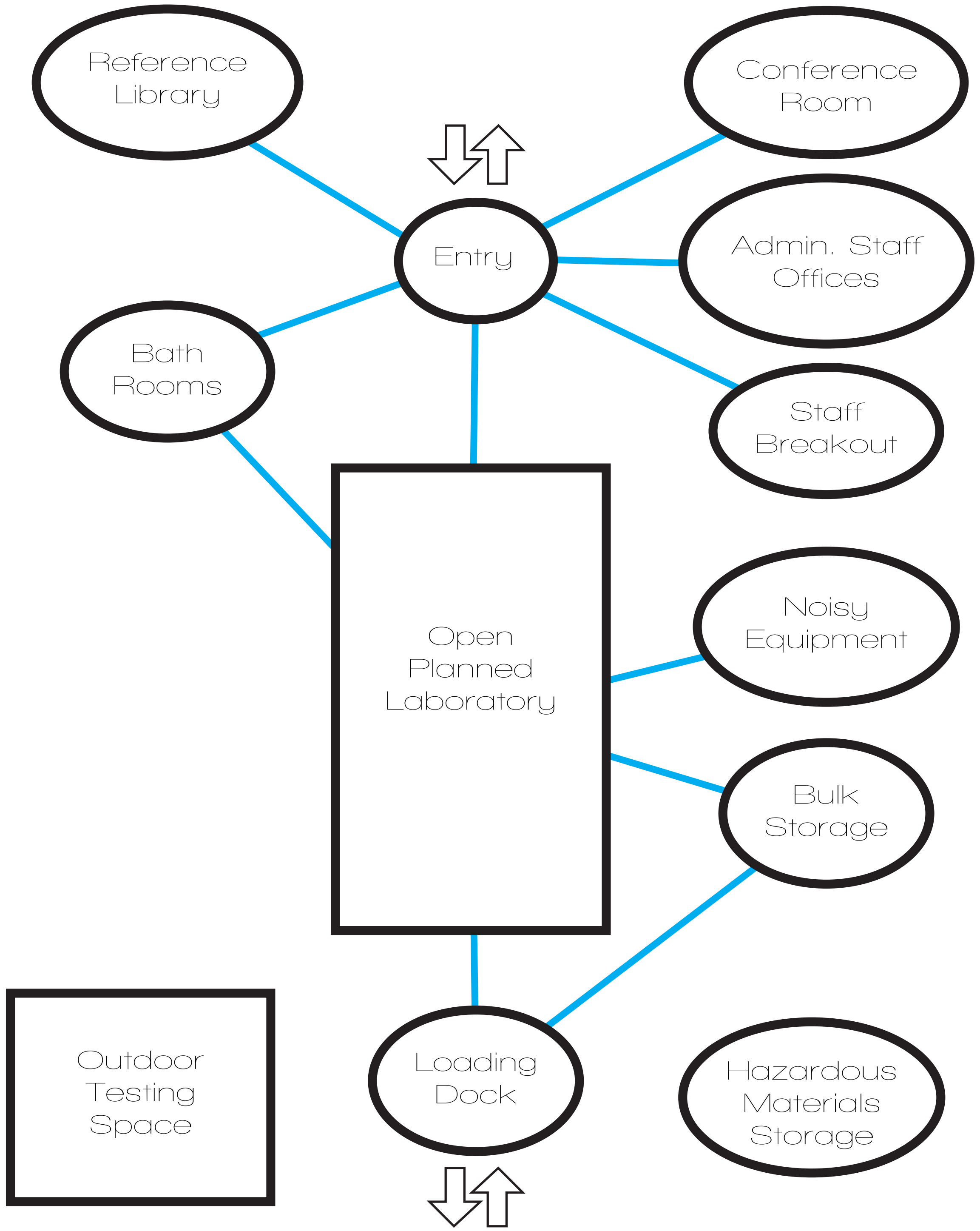


Fig. 25

Final Images

Interaction Matrix

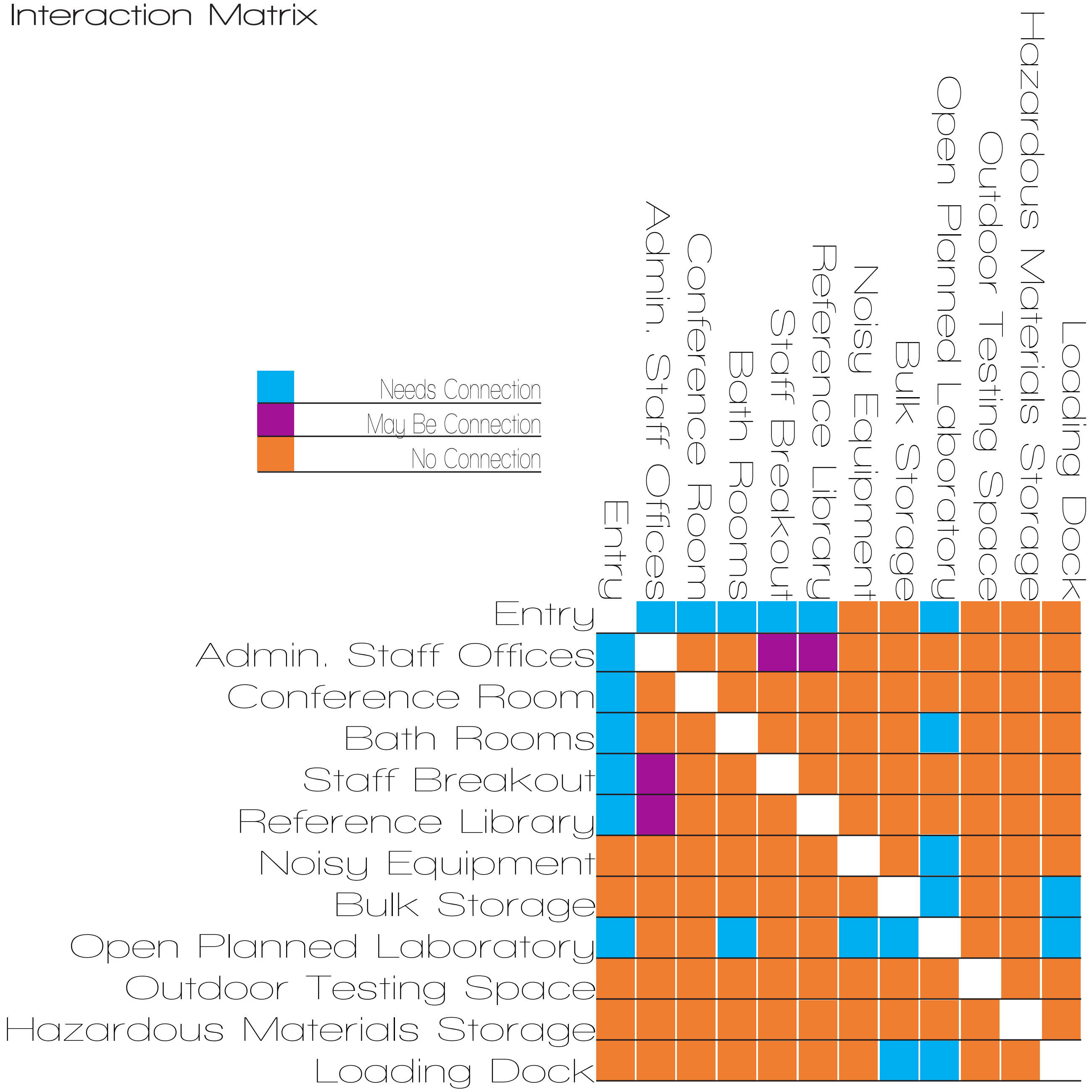
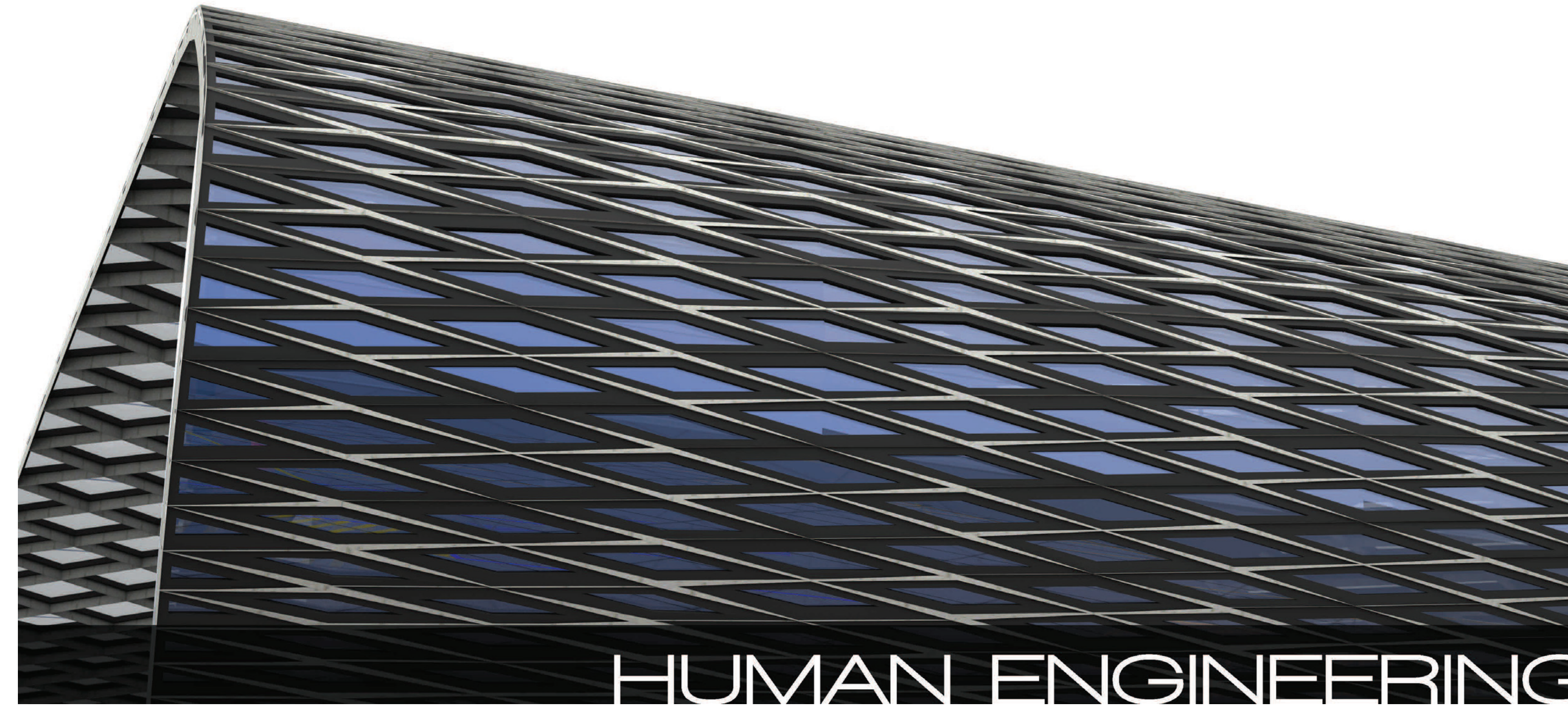
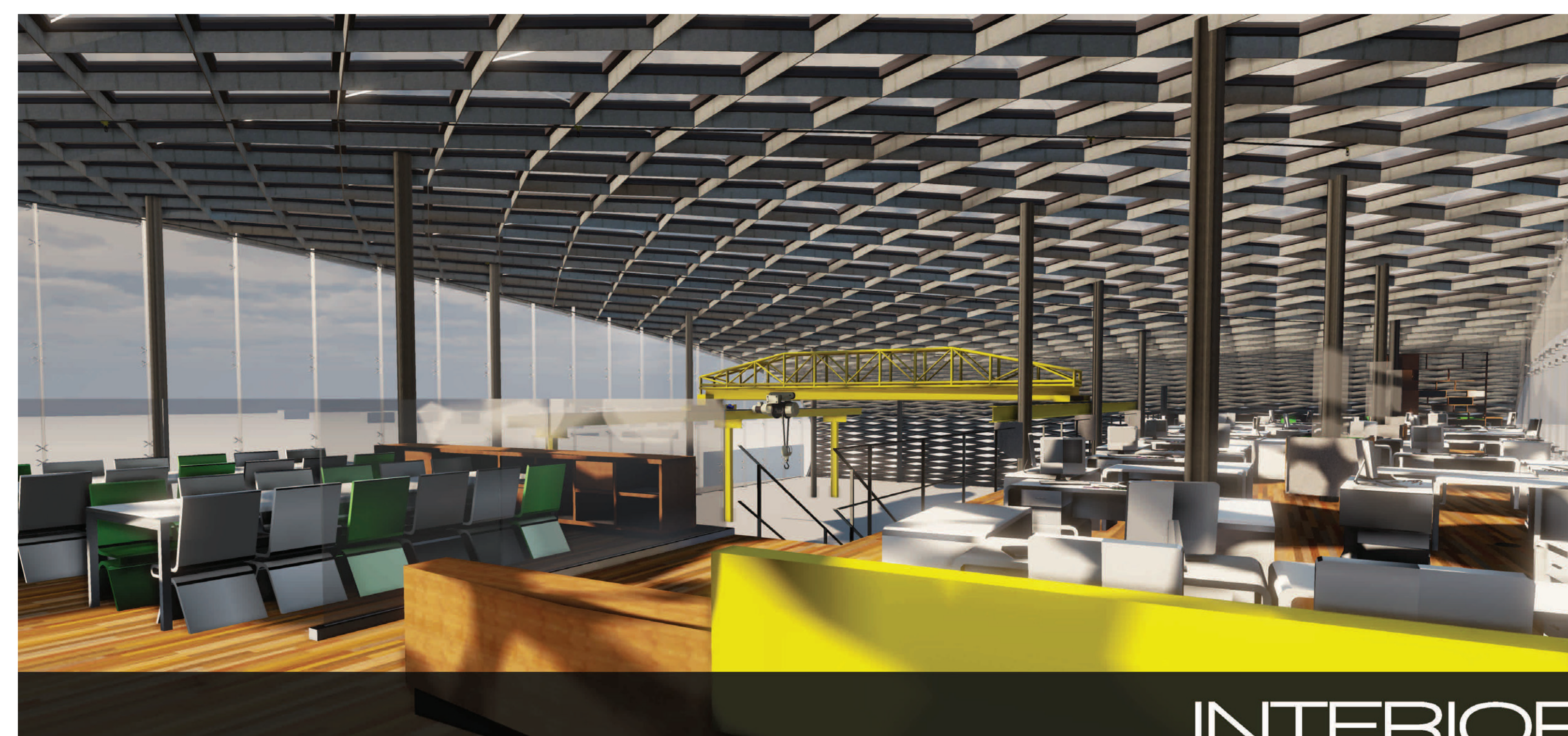
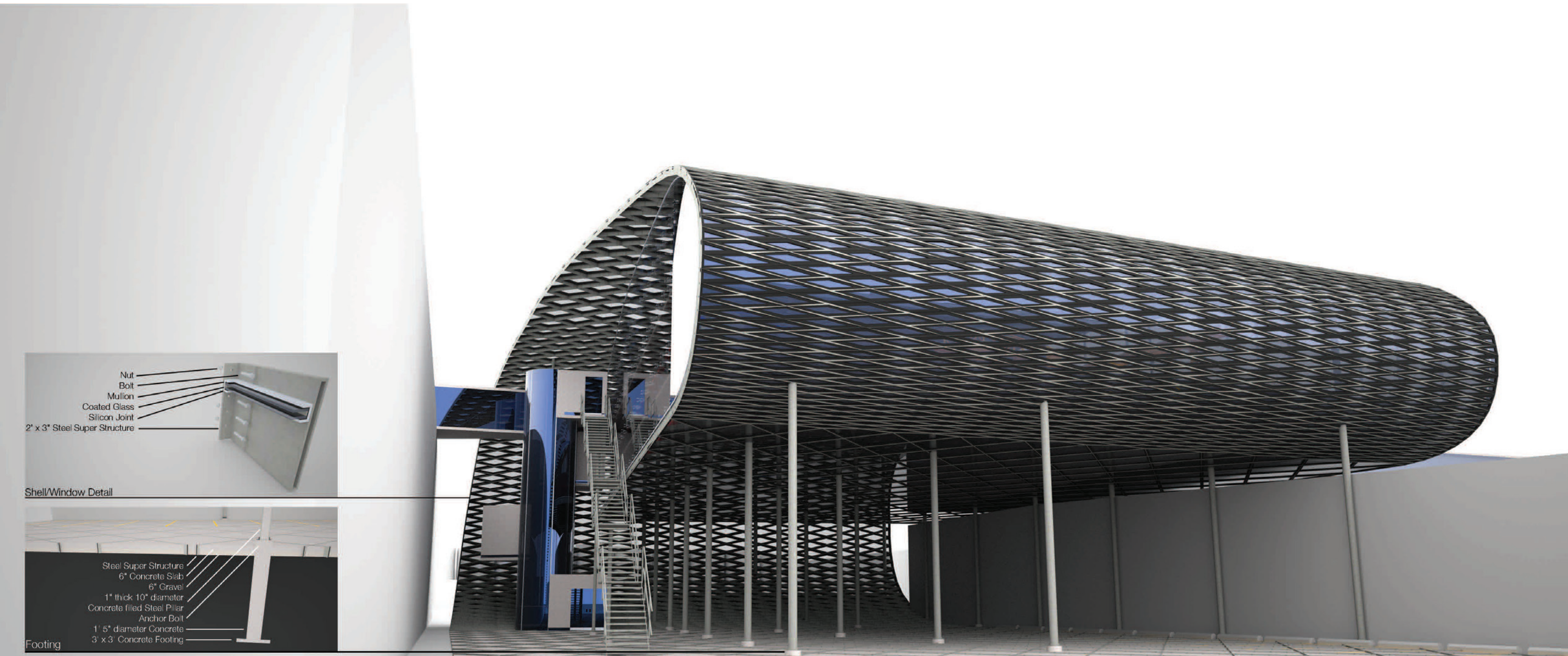


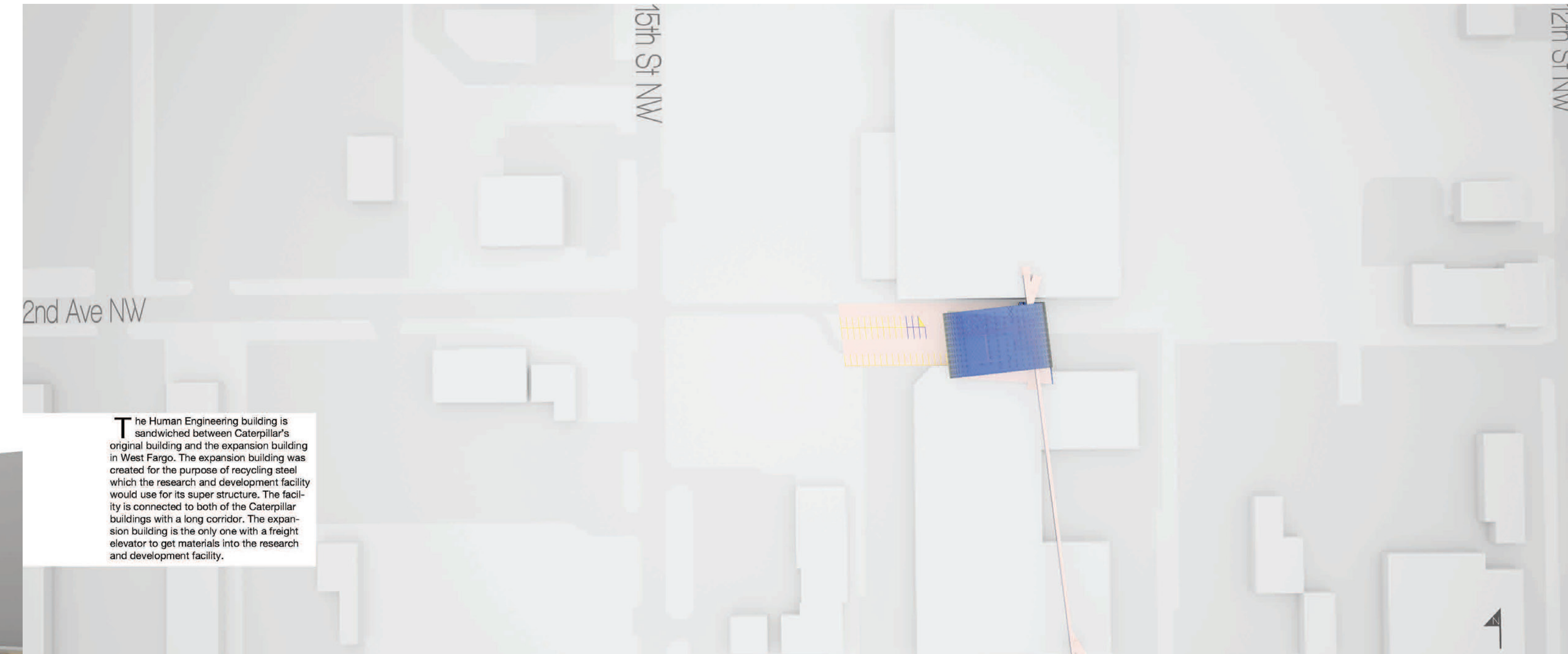
Fig. 26





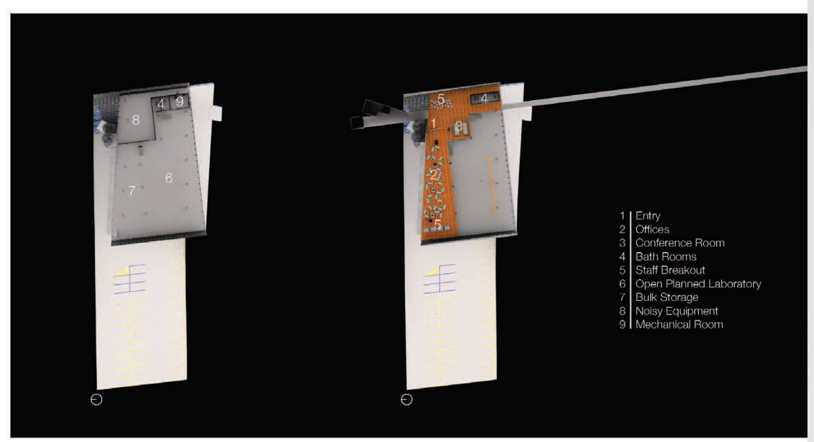


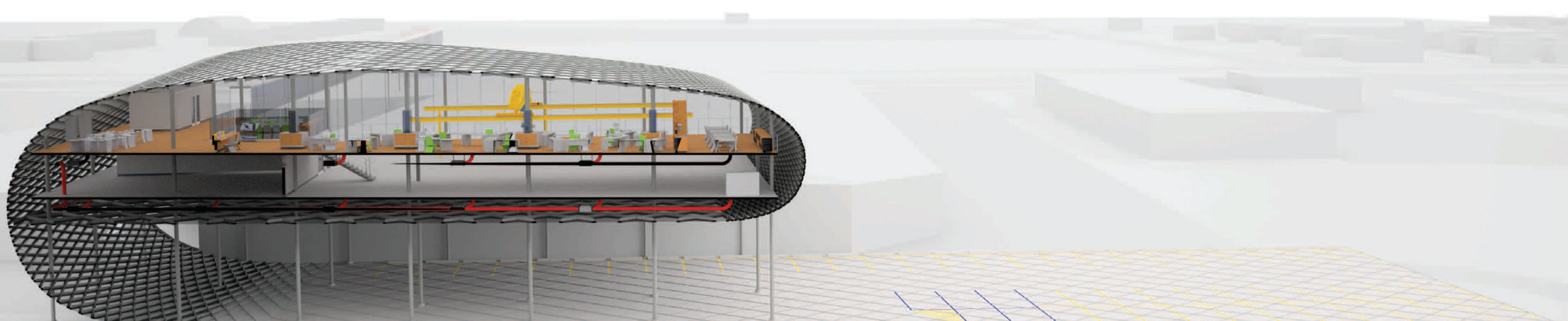
ENTRANCE



The Human Engineering building is sandwiched between Caterpillar's original building and the expansion building in West Fargo. The expansion building was created for the purpose of recycling steel which the research and development facility would use for its super structure. The facility is connected to both of the Caterpillar buildings with a long corridor. The expansion building is the only one with a freight elevator to get materials into the research and development facility.

SITE





Architecture 772 Design Thesis
Spring Semester 2012
Dusty Austin
Regin Schwaen

Software Used
Adobe InDesign, Adobe Photoshop, Autodesk 3DS Max Design, Autodesk Revit, Google SketchUp Pro, Maxwell Rendering, Unreal Development Kit

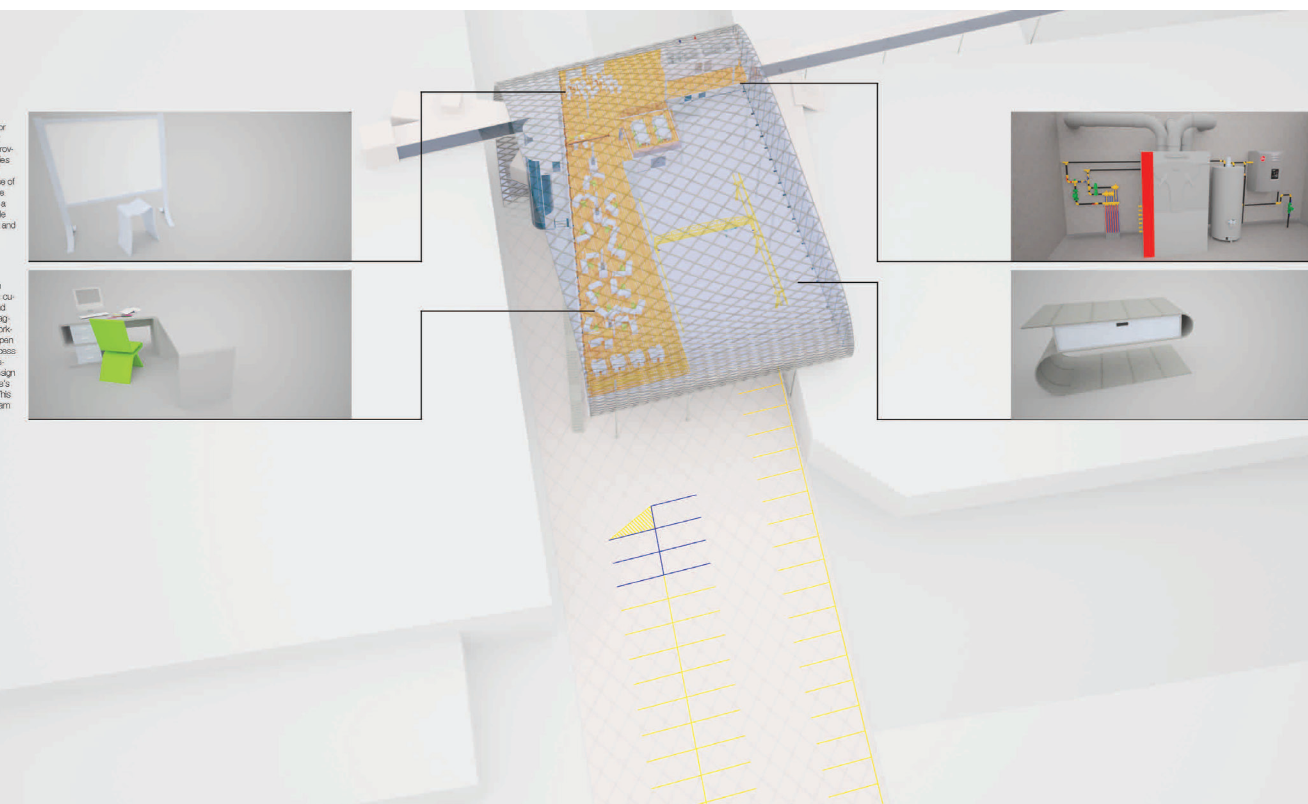
PERSPECTIVE SECTION/PLANS

Staff Breakout

The staff breakout space is used for gathering the researchers together and brainstorming new and/or improving on projects. One of the strategies to encourage alertness and critical thinking that I am applying is the use of stools. With chairs people feel more comfortable to lean back and take a passive approach to critiquing, while an upright position keeps one alert and engaged.

Office Space

The researcher's office space is an open space, without walls or office cubicles to encourage productivity and the ease of flexibility. Walls often stagnates innovation, separating the workers from one another. While with open floor plan the researchers have access to one another and it promotes creativity. Being able to see others' design work encourages stimulation of one's own mind furthering their abilities. This allows the workers to work as a team as well as on their own.



Mechanical Room

In the mechanical room there is a heat recovery ventilation unit, an instant water heater, and a radiant heated floor system. The heat recovery ventilation unit is always ventilating fresh tempered air throughout the facility, this system allows the building to have the freshest air possible. Since most the flooring in the building is concrete it make a great choice for a radiant heated floor system since it is a very good thermal mass.

Work Bench

Since the building is a research facility projects will come and go therefore the building is designed so that it can accommodate all sorts of different projects. Module units have been incorporated into this design as to accommodate multiple projects and offer more space to the workers.

Reference List

Text

(2011, 10 31). Retrieved from International Ergonomics Association: http://www.iea.cc/

Archilab. (2002). Archilab's Futurehouse. New York: Thames & Hudson.

Bowyer, D. A. (n.d.). Rep-Rapping: create almost anything with a new 3D printer. Retrieved December 6, 2011, from University of Bath: http://www.bath.ac.uk/research/features/reprap.html

Braun, H., & Gromling, D. (2005). A Design Manual Research and Technology Buildings. Basel: Birkhauser - Publishers for Architecture.

Brindle, S. (2004). Paddington Station: Its history and architecture. English Heritage.

Brown, L. F., & Davies, R. L. (1961). The Design of Research Laboratories. New York: Oxford University Press.

City of West Fargo. (n.d.). History of West Fargo. Retrieved from City of West Fargo: http://www.westfargond.gov/NewsandInfo/History/tabid/66/Default.aspx

Daniel Watch, P. (2008). Building Type Basics for Research Laboratories. New Jersey: John Wiley & Sons, Inc.

Griffin, B. (2005). Laboratory Design Guide. Burlington: Architectural Press.

Hausmann, K., Adam, J., & Juttner, F. (2004). A Design Manual Industrial Buildings. Medialis: Birkhauser - Publishers for Architecture.

Herbert L. Smith, Jr. (1958). Buildings for Research. F. W. Dodge Corporation.

Holland, G. (2008, September 4). Crystal Palace. Retrieved from BBC: http://www.bbc.co.uk/london/content/articles/2004/07/27/history_feature.shtml

Universal Designers and Consultants, I. (2011). http://www.universaldesign.com/. Retrieved from universaldesign.com: http://www.universaldesign.com/

Panero, J., Zelnik, M.(1979). Human Dimention & Interior Space. New York: Crown Publishing Group.

State Historical Society of North Dakota. (n.d.). History of North Dakota. Retrieved from State Historical Society of North Dakota: http://history.nd.gov/

Tilley, A. R. (1993). The Measure of Man and Woman: Human Factors in Design. New York: John Wiley & Sons.

USGS. (2006, August 03). Climate of North Dakota. Retrieved November 30, 2011, from USGS Science for a Changing World: http://www.npwrc.usgs.gov/resource/habitat/climate/sunshine.htm

Windfinder.com. (n.d.). Windfinder - Wind & weather statistic Fargo Airport . Retrieved from Windfinder.com: http://www.windfinder.com/windstats/windstatistic_fargo_airport.htm#

Images

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http://www.geograph.org.uk/photo/2039116
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http://www.architecture.com/HowWeBuiltBritain/HistoricalPeriods/Victorian/LeisureAndPleasure/TheCrystalPalace.aspx
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Trachtenberg/Hyman (1986). Architecture from Prehistory to Post-Modernism. Harry N. Abrams.
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http://www.avenuedstereo.com/modern/paris1889_machines.jpg
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