BIOENGINEERING BUILDING

Eastern Region, USA

VICTORIA RIEDINGER

Lighting/Electrical

Advisor: Dr. Kevin Houser

Tech Report 4b

January 20, 2016

EXECUTIVE SUMMARY

This report outlines the proposed redesign of the Bioengineering Building. The design includes a lighting depth, an electrical depth, a structural breadth, and a mechanical breadth. To supplement these areas of study, a Master's breadth and an Honors study will be added to the project scope. These areas will be studied and developed through the Spring 2016 semester and finalized and presented in the spring.

LIGHTING DEPTH

The lighting depth will include the redesign of the lighting in four spaces, all located on the first floor of the building:

- Exterior Plaza
- Lobby
- Flex Classroom
- Flex Lab

The designs will be developed fully from schematic design through construction documentation. The designs will incorporate the studies done in the various breadths to create a successful energy efficient design.

ELECTRICAL DEPTH

The electrical depth will conduct two redesigns in the building which will accommodate the changing loads and energy consumption. The first will be a branch circuit study to determine how to resize the panelboards and feeders to cover the new lighting design. The second is the addition of a photovoltaic array on the roof of the building which will help reduce energy consumption.

BREADTHS

To satisfy the MAE requirements, a daylighting study will be done in the Flex Lab to determine the influence of daylight in the space and the needs to control it. Using this data, the structural breadth will develop a new façade system for the first floor that will provide shading to maximize the amount of good daylight allowed in and control the thermal load. The mechanical breadth will study the thermal load from daylight on the first floor and the energy savings after the new façade is designed. To satisfy the Schreyer Honors Thesis requirements, preliminary research has been done to study in effect daylight has on occupants and the various façade shading systems that can be used to control it.

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BUILDING OVERVIEW

BUILDING NAME—CANNOT BE PUBLISHED
BUILDING LOCATION—CANNOT BE PUBLISHED
BUILDING OCCUPANT NAME—CANNOT BE PUBLISHED
OCCUPANCY TYPE—RESEARCH FACILITY
SIZE—183,000 GSF
FLOORS ABOVE GRADE—6
CONSTRUCTION DATES—JULY 2015-MARCH 2017
TOTAL COST—$120,000,000
PROJECT DELIVERY METHOD—DESIGN-BID-BUILD

PROJECT TEAM

OWNER—CANNOT BE PUBLISHED
GENERAL CONTRACTOR—CANNOT BE PUBLISHED
ARCHITECT
MECHANICAL ENGINEER—BALLINGER
PLUMBING ENGINEER http://www.ballinger-ae.com/
ELECTRICAL ENGINEER
LIGHTING DESIGNER—THE LIGHTING PRACTICE
http://thelightingpractice.com/

LIGHTING DEPTH

The lighting depth of this thesis design focuses on four spaces in the Bioengineering Building. The first studied space is the Exterior Plaza which wraps around the eastern and southern side of the building. The next three spaces are located on the first floor of the building and are directly connected to each other. They include the Lobby, Flex Classroom, and Flex Lab.

LIGHTING DESIGN CONCEPT

The main principal of bioengineering is to find ways that the structures and functions of living organisms can be used as models for the design and engineering of materials and machines. The specific research done in this building combines the principles of biology and the tools of engineering to create usable and practical devices that improve the function of the human body, therefore enhancing the quality of life. With the research done in the building, there's a clear emphasis on the human body and the study of maintaining a consistent flow and function of its various systems. A building functions very similarly to a human body, requiring a connection and flow between its various interacting parts which rely on each other to stay 'healthy'. Because each of the studied spaces are directly connected to each other, that flow is very important to the design, and like the body, each space must work together to create one cohesive design that represents the purpose of the building.

EXTERIOR PLAZA

Much like people, the exterior of a building expresses the idea of its purpose and design. The landscape doesn't define the building, but it's the first impression that visitors have. Because of this quality, the plaza symbolizes a persons hair. It acts as an identity for the building but doesn't represent everything that goes on within.

Because the Exterior plaza is an outdoor space, transition and safety are main concerns for visitors. Wayfinding and social gathering will be the main purpose for the space. The lighting must satisfy the light levels and energy standards that will provide enough illumination for easy transition and visual acuity during the evening and night hours. The design of the Plaza will be to compliment the architecture of the building without throwing too much light on the façade. Because the façade is mostly curtain wall, light will spill out into the plaza. While over lighting is a concern, applying light to the transition areas and entryways is necessary. Because people will be traveling from building to building like in a campus setting, light focused on the pathways will help direct them. The space should also feel comfortable enough for people to stop and sit on the benches or gather in groups.

Architectural light columns line the pathways to direct people throughout the space. They'll be about 15 ft tall so they won't block very much of the façade. They'll provide general illumination as well as provide linearity along the façade of the building which will help direct people down the paths to the surrounding buildings. The benches on the site will be lined with tapelight, drawing people to those areas where they can gather. At the social table near the main entrance, linear lensed fixtures will be integrated into the wood paneled benches, washing the platform with light. This will encourage gathering in that space as well and creates a point of interest near the main entry to the building. Downlights will be installed in the canopies to provide illumination at the building entries. Circular ingrade led lighting leads people to the entrances of the building, getting more concentrated as you get closer to the doors. This also mimics the point at which hair joins the body (exterior plaza joins the building) and where the transition through the rest of the body (building) can begin.

LOBBY

The lobby can be considered the heart of the building, where the main gathering of visitors takes place. This space is the main entry and branches off to the rest of the building. Veins and arteries all branch from the heart creating pathways to the rest of the body carrying blood, oxygens, and nutrients through the body. The large lobby is the first thing people will see when they enter the Bioengineering Building. Circulation is the main task so it's important to create an eye-catching space that also facilitates movement through the building.

Because it's a double story lobby, occupants should feel like they're walking into a grand and welcoming entry. Wayfinding and transition are the main purposes for the space, while it also serves as a welcoming to the entire building. This space should give visitors an idea of what happens within, encouraging their movement and curiosity through the space. The lighting should help direct people toward their intended destination within the building. The grand stairway and connected hallways are important points of interest for transition through the space that require specific lighting to emphasize them. One of the main considerations for this space is the relationship to the surrounding rooms. From the exterior, the lobby is extremely visible and opens directly to the Flex Lab, which is a showpiece for the building. Minimal spill light should leave the lobby and fixtures should compliment the style and performance of the ones used in the lab.

Fiber optic cable will be hung from the ceiling to create a visually interesting design to the space. It will originate from the stairway core and weave through the hallways, drawing visitors eyes to the points of transition. They will represent the veins in the circulatory system that flow through the body, helping to create a flow through the space to aid visitors in their transition to other areas of the building. A plaster-in asymmetric slot will throw light onto the ceiling above the staircase drawing visitor's eyes upward. Downlights with specular reflectors will be placed throughout the lobby to give general illumination to the space without creating bright spots of light on the ceiling. This will allow the fiber optic fixture to pop in the space. A cove will be built around the center core to wash light up the wood panel walls, bringing out the texture in the space. Daylighting integration will be important in this space as well, with the curtain wall façade wrapping around the entire first floor. Controls will be utilized to vary light levels to maximize the use of daylighting and energy savings.

FLEX CLASSROOM

The flex classroom is a very flexible space, much like our lungs. As humans breath, the lungs are continuously expanding and contracting to let air in and out. They are also split into compartments. Air flows in through the windpipe into the branches that filter into the lungs. The organ is then broken up into two initial compartments which is the most obvious break down (the two lungs). Then within those lungs, air is filtered through smaller and smaller branches ending in air sacs and passing oxygen into the bloodstream. This breakdown mimics the way the flex classroom can be separated into various spaces. Beginning with one large space, it can then be broken into two or four separate rooms.

What separates the Flex Classroom from the other three spaces in the study is it's extreme versatility. The classroom itself has three different orientations that satisfy the different uses of the space. The space can be used for lectures, smaller classroom instruction, or large events. Whiteboards, projection screens, presenters and classroom writing/reading tasks will be utilized within the space, requiring a variety of visual scenes. The lighting will fit into every orientation of the space, providing various light settings. Like the Flex Lab, the Flex Classroom also has the ability to open directly to the lobby through the large openings on the east and west sides of the room. When those large doors are open, the first floor becomes one large space used for public events. Downlights will be placed in the ceiling over the two large entryways to fill in the gap with light between the classroom and the lobby. These fixtures will be able to dim down in order to provide some drama to the space when needed for various events. Downlights will also be placed within the classroom symmetrically to accommodate the partition walls needed to separate the space. This will also provide even illumination needed for reading and writing. Cove lighting will run in the North-South direction in the room, washing the ceiling with light and making the 21' tall space feel large and grand for events.

When all the partition walls are down there are four separate classrooms that need to be lit. When only the middle partition wall is down, two larger classrooms are formed which still need similar illuminance levels for the tasks. The whiteboards and projection screens will have minimal direct light on them, which will minimize glare and visual discomfort for occupants. Visual clarity is important on both the speaker and the presentation. Adjustable downlights will be located along the perimeter of the room in order to provide adequate illumination on the various presenters within the space.

One of the most important criteria of this space is the flexibility of the systems being designed. Controls will be designed for the space so that various scenes can be set for the different uses of the space. Fixtures will have the ability to dim and switch on and off when needed for lecture, classes, and public gatherings.

FLEX LAB

The flex lab serves as the eloquent show piece of the building. It has the ability to convey and communicate any message to the public that the building's users want it to. Like a mouth, the lab provides a flow of information from the people that use the space to the building's visitors, informing them about its internal identity. Visitors are able to observe some of the work and research being done in the building easily. The western wall of the lab is completely open to the lobby, allowing anyone to filter through the space.

The Flex Lab is both a showpiece and a work space for the building, but the priority for this room is the research work that will be done. Students using the space will be performing research using small tools and some heavy machinery on individual work benches. The higher detail work done in this room will require higher light levels than will be needed in many of the other spaces which also allows for a higher Lighting Power Density. Individual lighting control is important as well so that the occupants working in the space can have a comfortable place to work. Flexibility is also necessary for the lab because of the movement in the space. At times, large equipment may be moved through the space, so lighting needs to be out of the way or movable. The lighting also needs to integrate with the mechanical equipment needed in the space so that the locations don't overlap.

A linear direct/indirect pendant will hang from the 30' ceiling providing light on the lab benches and the ceiling. This will make the space feel grand and open, while illuminating the mechanical equipment around the room. This exposed equipment is an important part of the function of the space and should be celebrated. Adjustable pop up task lighting in the lab benches will allow the occupants to personalize their space and have access the amount of light that they desire in their work space. It will also allow them to keep the fixtures out of their way when they don't need more light, giving them more space at their tables to work. Accent lighting will also be placed on the columns to help to highlight the mechanical equipment in the space and draw occupants eyes upward into the tall room.

Daylighting is an important consideration for this space as well. A curtain wall lines the entire eastern wall, allowing for a large influx of daylight through the day. Controls will be used to lower energy consumption and utilize the helpful sunlight coming into the building. A study of the façade will also be done to help minimize glare and visual discomfort in the work environment.

SCHEMATIC DESIGN FEEDBACK

Kevin Houser—Thesis Advisor

-Circulation routes added to the plan are very helpful! Nice improvement in orientation
-Didn't like the font choice. The italics make it more difficult to read than a simpler font
-Exterior, refined explanation in response to Tech III presentation. Good!
-Lab space: "entire right hand wall is glass". Better to give the orientation directly. You later said it was the eastern wall. Consider placing north arrow on drawing (which you didn't) and reinforcing with your words (which you did)
-Good conclusions
-Overall: I could see you developed the ideas and presentation in response to Tech III presentation, making a strong presentation even better. Presented concepts that were responsive to task functions, design criteria, architectural opportunities, and were tied together and motivated in an appropriate metaphor. Presentation was clear and easy to follow. Good graphics, appropriate level of detail. Nice work. Keep at it.

Sandra Stashik

-Good job orienting us to the project. High level concept good, and explained well
-First person that mentioned controls.
-Exterior: in grade and large overhang, how is this to be dealt with? Need to get light on faces as people move in and out of building. Maybe add light under overhangs.
-Liked the view of all three lobby designs side-by-side.
-Downlights don't always work under stairs. Downlight pattern was similar in all three designs, can push this further– are downlights the only way to go? Can you light from adjacent wall?
-What do you do with the wood wall? Don't forget to design with the curve in mind.
-Liked the uplighting and drawing attention upward
-Flex classroom: pleased that you mentioned controls and need for different light levels. Think about vertical surfaces– do you need to put light on the vertical surfaces?
-Be careful with fixture representation in flex classroom render. Line of light in coves can be misleading.
-Had some great renderings to use from the architect
-Flex lab: mentioned that glare could be an issue, but are there screens or shades? Liked the concept of the task light that can go out of the way because it doesn't make the space any busier
-Show the uplighting on the columns more clearly

Lee Brandt

-Liked/disliked the body concept. Some people may think hair is gross? Liked how it was presented though.
-Not much on the exterior. You had the right layers.
-Lobby 1: seemed liked hair instead of veins
-Lobby 3: probably liked this design the best
-Curious how the divisions work in the flex classroom
-Liked how all the spaces connected
-In most projects designers use a pallet of fixtures that need to become a toolkit used in different spaces. You seemed to understand and incorporate that type of idea.
-Flex lab: liked the shape of the luminaire
-Perspective of the flex lab is slightly misleading. Probably need a different perspective or show on key plan
-Followed and enjoyed your presentation and execution

SCHEMATIC DESIGN FEEDBACK

Mike Barber

-Connections: How is the building relate to the adjacent surroundings. (Saying that it's on a campus is helpful, so we know it's not on a busy intersection and that most traffic is pedestrian)
-Think about how the social table will glow with the fixture chosen
-Don't just take what you're given and add light to it. Can you reimagine this with light as an integral component?
-Draw smaller circles for the downlights
-How will the flex classroom be broken into 4 spaces? Think about it from a controls perspective. Need to eventually show as the smaller spaces as well.
-Fiber optics in lobby: is it intended to be exposed or will they be integrated into building materials? Heavy portals in flex classroom space. Minimize them. Don't necessarily need to put holes in all of the portals. Can create some magic when there is darkness between the spaces.
-Use specular reflectors instead of black reflectors in lobby

DESIGN PROCESS & TOOLS

SCHEMATIC DESIGN

Hand sketching on tablet using architect renders & Photoshop

LIGHTING CALCULATIONS & MODELING

3D AutoCAD, Revit 2014, AGi32

RENDERINGS

Revit, AGi32, & Photoshop

DOCUMENTATION

3D AutoCAD, Revit 2014, Microsoft Powerpoint, Microsoft Publisher

DAYLIGHTING ANALYSIS

Daysim & AGi32

ELECTRICAL DEPTH

The proposed electrical depth will address two design changes within the electrical system. The first will be a branch circuit redesign to accommodate for the new lighting design, and the second will be the addition of a photovoltaic array on the roof.

BRANCH CIRCUIT REDESIGN

The redesign of the lighting in the four spaces will require the installation of new fixtures with loads different than the existing, resulting in different loads on the feeders and panelboards. A redesign of the branch circuits will be needed to accommodate for these new loads and may affect the sizing of the panels and feeders.

PHOTOVOLTAIC ARRAY

The large amount of flat roof space available on the building could provide an ideal location for the installation of a photovoltaic array. It would be able to supply energy to the building, reducing the energy usage and cost to operate. A study will be done to determine the optimal location and angle of placement to maximize the energy captured. Because of the height of the building they will minimally impact the architectural look of the building.

MAE BREADTH– DAYLIGHTING

Because the Flex Lab has more strict lighting requirements for highly detailed work and the use of machinery, the daylight in the space needs to be controlled. The entire eastern wall of the lab is a 30’ curtain wall, which will allow for a significant amount of daylight into the space, especially in the morning. This could cause glare and thermal comfort problems throughout the year which could impact the ability of occupants to complete their research. A daylighting study will be done on this space to analyze the current daylighting influence and determine the need for a shading strategy on the 30’ curtain wall. Using this analysis, a new façade will be designed for the first floor to maximize the influx of good daylight and minimize the glare and thermal gain in the space. Learning material from the AE 565 Daylighting masters class will be incorporated into this study.

STRUCTURAL BREADTH

Based on the result of the daylight analysis, a new façade system will be designed for the first floor of the building. Because the first floor façade is different than the remaining floors, the architectural look of the building will not be compromised. The new façade will be designed to maximize the helpful daylight allowed into the first floor, which will help reduce energy usage and cost. A shading strategy will be applied to the new façade to minimize glare and visual discomfort for occupants. Because the façade will be designed for structural purposes, it will need to be checked for loads that may influence its stability.

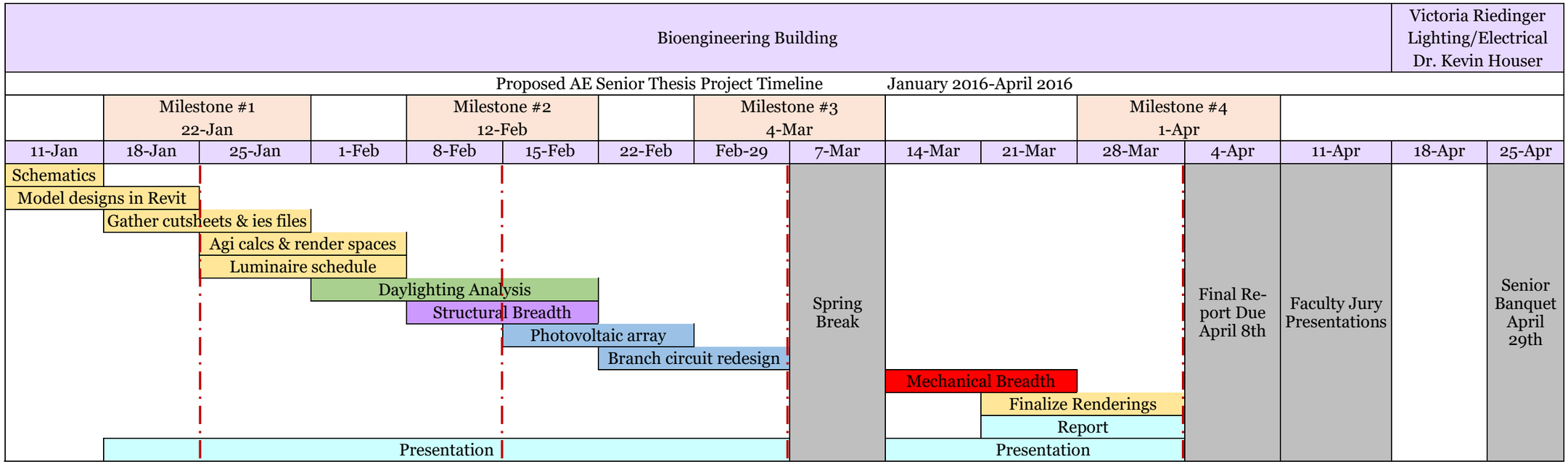
MECHANICAL BREADTH

The design of a new façade system will minimize the harmful influence of daylight on the first floor. This change in daylight control will affect the thermal loads into the building as well, helping to reduce energy consumption and thermal discomfort. The change in thermal influence will be studied to determine how much influence daylight currently has on the space. This will be used toward the design of the new façade to help minimize thermal discomfort and increase energy savings in the design.

SCHREYER HONORS THESIS

To satisfy the requirements for the Schreyer Honors College Thesis preliminary research was conducted on the influence of daylight on building occupants and the various shading and façade techniques used to control it. This research will be used to guide the redesign of the first floor façade to maximize the influence of good daylight into the building. A paper was completed to summarize this research and serves as the first chapter of the final Schreyer thesis. The entirety of the thesis will contain the initial research along with the individual depth and breadth topics completed for the Architectural Engineering Thesis.

PROJECT TIMELINE



Legend
Lighting
Electrical
Daylighting
Structural
Mechanical
Document
General
Milestone

Milestones	
1	Schematic designs complete and modeled in Revit. Beginning of DD phase
2	DD, all lighting calculations, and luminaire schedule completed. Daylighting started
3	Structural breadth, and electrical depth completed
4	Mechanical breath and final documentation completed. Begin presentation