December 6, 2010

SENIOR THESIS FINAL PROPOSAL

PENN STATE AE SENIOR THESIS

SUPPORT SERVICES BUILDING

PENN STATE MILTON S. HERSHEY MEDICAL CENTER – HERSHEY PA

WILL LAZRATION

CONSTRUCTION MANAGEMENT

DR. RILEY

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EXECUTIVE SUMMARY

Senior Thesis Final Proposal is intended to discuss the analyses that will be performed on the Penn State Milton S. Hershey Medical Center's Support Services Building. Each of the first three analyses has been selected in order to add value, decrease schedule duration, or fix a constructability issue within the project. Analysis four has been selected in order to incorporate more sustainable techniques into the Support Services Buildings and make it Penn State's first "Net-Zero" energy building.

ANALYSIS 1: ***RE-DESIGN OF FOUNDATION SYSTEM***
PSUHMC's Support Services Building was set on a micropile foundation system based on the recommendations of the Geotechnical Report. The report however was based on column loads that far exceed actual column loads for almost two-thirds of the structure. Based on Alexander's past construction experience in the Harrisburg/Hershey area, they felt that the micropile foundation system was overkill based on the size of the project. It is the belief of the construction team that the project could have seen a significant cost savings is a different foundation system was utilized. Therefore, the goal of this analysis is to re-design the foundation system and analyze cost and schedule implications of the new design.

ANALYSIS 2: ***ELIMINATION OF OFFSET ROOF & ROOFING MATERIAL SUBSTITUTION***
The Support Services Building utilized HMC's standard cold-applied asphalt roofing system. This system is expensive and has major schedule implications with installation. Also, a 3,600 SF section of roof was offset 5' to hide mechanical equipment. The goal of this analysis is to research and compare several roofing systems and determine to best choice for the project based on schedule, cost and sustainability. It is also a goal to determine the cost and schedule implications of offsetting the roof, and to determine if the offsetting the roof was necessary.

ANALYSIS 3: ***SCHEDULE ACCELERATION OF EXTERIOR ENCLOSUE***
Upon completion of steel erection, the critical path of the project moved onto the Exterior Enclosure. The exterior enclosure must be completed in order to finishes to take place on the inside. Losing 5 weeks due to issues with micropile installation has caused the construction team to pursue methods to help improve the schedule. The goal of this analysis is to determine an effective way to add crews/manpower, material substitution, and constructability methods in order to decrease the duration of the exterior enclosure. Local labor availability as well as cost implications will be considered and compared.

ANALYSIS 4: ***DESIGN STUDY TO MAKE PSU'S FIRST NET-ZERO BUILDING THROUGH PHOTOVOLTAIC'S***
PSUHMC's Support Services Building is on track to achieve a LEED Certified rating under LEED Version 2.2 upon completion. However the project has utilized very few sustainable techniques that could provide financial benefits to Hershey Medical Center or Penn State. This project, because of its smaller size, is a great opportunity for Penn State to showcase its technology and research capabilities of more sustainable buildings. The goal of this analysis is to design a preliminary PV system and solar hot water system to help make the Support Services Building Penn State's first "net-zero" energy building. Although it would increase the cost of the project, it is a great opportunity for Penn State to become a leader amongst major universities with a "net-zero" building.

See **Appendix A** for a detailed description of the imbedded Breadth Studies within this proposal.

PROJECT BACKGROUND

Penn State Milton S. Hershey Medical Center is a state-of the-art research hospital and a branch campus of The Pennsylvania State University that houses the university's College of Medicine. Founded in 1966 by the Pennsylvania State University in large parts from a $50 million dollar gift from the Milton S. Hershey Foundation, the medical center has grown to over 550 acres, 8,800 employees, and the College of Medicine emits over 600 students annually. Figure 1 below shows the entire HMC campus. Overseeing the project for the University/Medical Center is the Office of the Physical Plant (OPP).

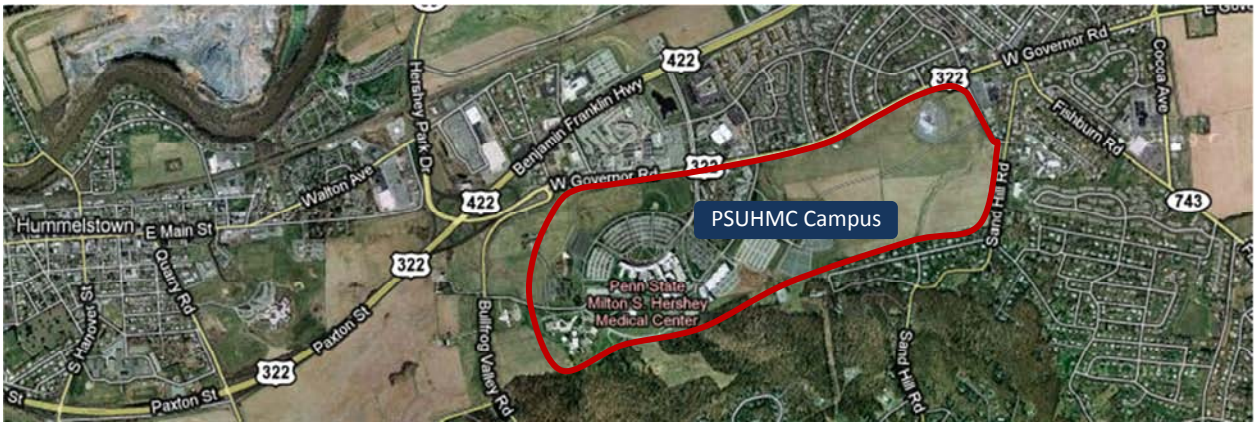

Figure 1: Arial View of Penn State Milton S. Hershey Medical Center & Surrounding Area. Image taken from Google Maps

In order to meet the demands of the aging/expanding medical center, several years ago the University's Board of Trustees approved the construction of several new buildings. One of those buildings was the Support Services Building. Seeing that the original shipping/receiving dock located underneath the main hospital was cramped, congested, and inefficient, the decision was made to relocate the main shipping/receiving dock as well as many of the medical center's support services to their own separate building. The new building will be able to keep up with the demands of the growing medical center.

PSUHMC's new Support Services Building is a 42,796 SF warehouse/office building located on a triangular shaped site on the northwestern corner of the campus. As shown in figure 2 at right, the northwestern portion of the building will be built over an existing tunnel that houses the main steam and chilled water lines for the hospital. In this area the building will be 3-stories tall with the lowest level (approx. 1000SF) matching the elevation of the existing tunnel floor. A service elevator servicing all three levels is located in this section of the building. The remaining portion of the building is 2-stories tall. To alleviate the congestion and provide better truck access the new shipping/receiving loading dock area located on the south side of the building will contain a total of eight truck dock doors. Included in the new building are a state of the art paint booth system and a high pressure spray wash station.

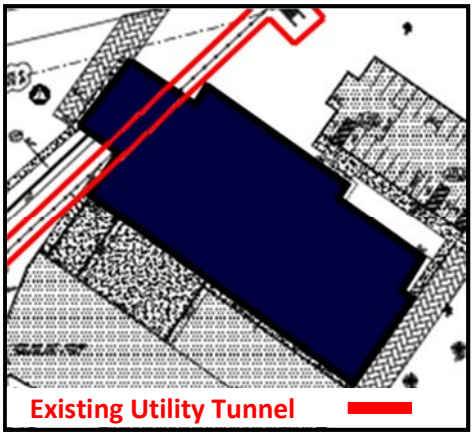

Figure 2: Location of Existing Utility Tunnel

Acting as the skeletal support for the building is its steel superstructure set on a micropile and concrete foundation system. In total there were 152 piles, 258 tons of structural steel, and 1,900 CY of concrete utilized in the structural system of the building. To achieve the modern look the medical center was looking for, the entire project is clad with a combination of a 4" masonry veneer, metal panels and glass

curtainwall. Figure 3 shown at right and on the cover page is the architects rendering of what they exterior of the building will look like. Interior finishes include exposed polished concrete and exposed ceilings, as well as conventional ACT ceilings, VCT floor tile, and ceramic tile. Upon completion the project is expected to achieve a LEED Certification rating under the LEED Version 2.2.

Figure 3: Architectural Rendering of Exterior

Another major part of the project is the re-alignment of Lion Life Drive with Campus Drive. Currently vehicles on Lion Life Drive have to wait at a stop sign and let vehicles on Campus Drive pass before turning left onto Campus Drive. With Lion Life Drive being the main access point to the hospital from west, the intersection quickly backs up during shift changes at the medical center. This is also the route in which all the medical supplies are delivered to the hospital. Figures 4 and 5 below show the existing intersection and what the new intersection will look like.

Figure 4: Old Lion Life Drive & Campus Drive Intersection

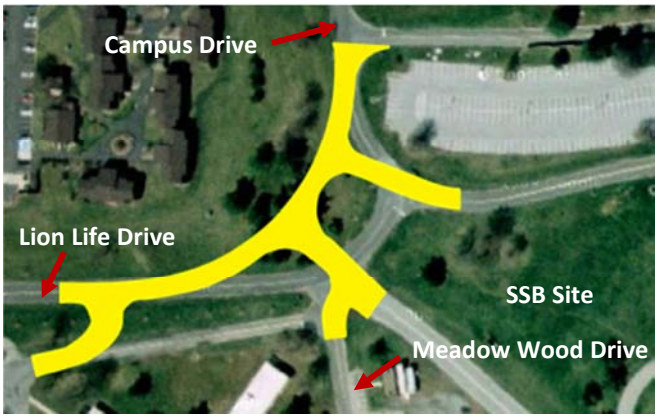

Figure 5: New Lion Life Drive & Campus Drive Re-Alignment

To construct the project Alexander Building Construction Co. from Harrisburg, PA was chosen as the CM @ Risk on the project with a GMP contract price of $14,395,331.00. Construction began June 1, 2010 and final completion is scheduled for September 31, 2011.

ANALYSIS 1: RE-DESIGN OF FOUNDATION SYSTEM

PROBLEM IDENTIFICATION

Design of the micropile foundation system for the Support Services Building was based on the recommendations of the Geotechnical Report. However the Geotechnical Report was based on a 350-kip column load near the tunnel and 250-kip column load elsewhere. Based on actual column loads given to Alexander by the structural engineer, the 350-kip column load near the tunnel is acceptable, but the 250-kip column load elsewhere is well above the 98-kip column load average for the remaining portion of the building. In fact there are several columns whose load is less than 50-kips.

Issues also arose with the installation of the micropiles on the project. Upon installation of all 152 piles, the Micropile Contractor began testing several piles as required by the project's specifications. Of the first several piles tested, it was discovered that nearly 1/3 of them were failing before meeting the design load, yet alone the load they were supposed to be testing at. To solve their problem, all 152 piles were tested and any pile that failed was pulled out and a new pile was installed which resulted in a 5-week increase in duration. It was discovered that the issue with piles failing resulted from the underlying bedrock. Because it was a karst formation, there were many voids within the bedrock. These voids filled with grout before the grout could get to the bottom of the pile, therefore the shortening the length of the pile, resulting in a weaker pile.

Alexander has constructed numerous buildings in the Hershey, PA area and felt that the micropile foundation system was overkill, and that the building could have been supported by different means. Total costs of the micropile contract were $791,301.00, and the Alexander team feels that if a different foundation system were utilized, the project could have seen a significant cost savings.

RESEARCH GOAL

The goal of this research is research foundations and their interactions with surrounding soils and to perform a preliminary foundation re-design for the Support Services Building and asses the impacts on schedule and costs.

METHODOLOGY

- Research Soil Conditions, Foundations and Transfer of Loads
- Review Geotechnical Report with representative from CMT Labs
- Contact Geotechnical Engineer and review project and considerations
- Review/analyze actual Column Loads
- Design a preliminary new foundation system based on findings
- Analyze building settlement with the new foundation design
- Analyze schedule and cost impacts of new foundation design

RESOURCES AND TOOLS TO BE USED

- CMT Representative – James Thorton – CE 397A Professor
- Geotechnical Firm who created Geotechnical Report
- Alexander Personnel
- AE Faculty – Structural
- Highland Associates – Project Architect and Structural Engineer
- Industry Professionals
- Applicable Literature

EXPECTED OUTCOME

After completing extensive research, consulting industry professionals, and an in-depth preliminary redesign of the foundation system it is believed that a re-design of the foundation system will result in both a cost and schedule savings. Although a re-design of the foundation system may require some means of soil improvement, it is still believed that overall the re-designed foundation system will be a cost effective solution to the micropile foundation system. A preliminary figure of a possible foundation re-design can be seen in figure 6 below.

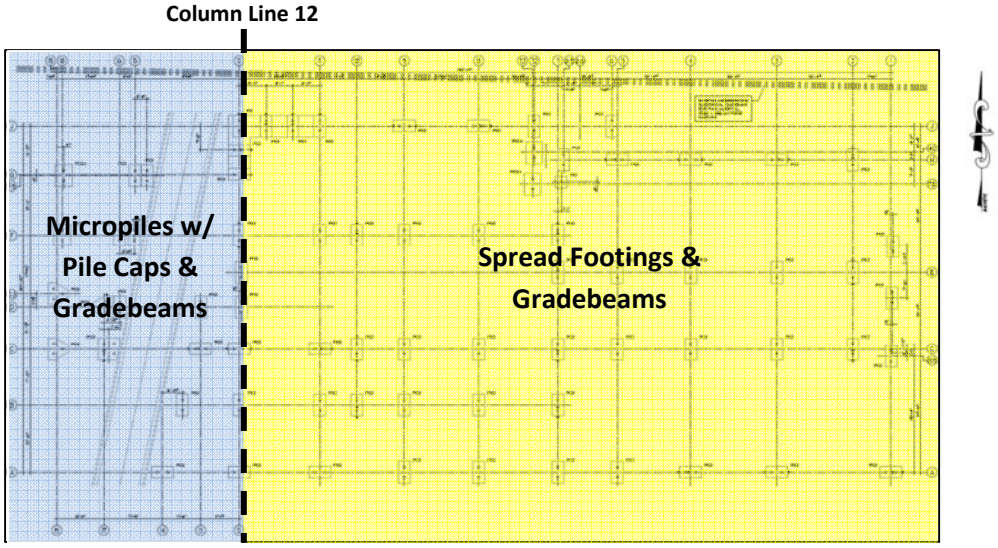

Figure 6: Potential Foundation System Re-Design

ANALYSIS 2: ELIMINATION OF OFFSET ROOF & ROOFING MATERIAL SUBSTITUTION

PROBLEM IDENTIFICATION

Mostly all of the mechanical equipment for the Support Services Building is located on the rooftop. To hide this equipment, the roof above the Central Campus Storage is offset 5'-0" below the main roof. What makes the sunken/offset roof a challenge to construct is the type of roofing used on the project. Hershey Medical Center utilizes a standard cold applied asphalt on all of their projects. With this type of roof, all of the parapet walls need to be installed prior to the installation of the roofing material, due to the interface detail between the two materials. Offsetting the roof also requires extra materials and added time to construct vs. if the roof was not offset. An added issue with the cold-applied asphalt roof is that it cannot be applied under certain temperatures. Giving the project schedule, the roofing has to wait until spring 2011 to be installed.

RESEARCH GOAL

The goals of this research is research different roofing material/systems and select a roofing system that that provides the greatest benefits to schedule, cost, and the environment and to analyze lines of site to determine if hiding the mechanical equipment it necessary, and to determine schedule and cost impacts associated with eliminating the offset roof.

METHODOLOGY

- Research different roofing systems
- Review NRCA's roofing guidelines and manuals
- Contact Manufacturers to gather more specific information
- Compare several types of roofing systems
- Select preferred roofing system
- Perform material takeoff for elimination of offset roof
- Develop a line of site study of mechanical equipment
- Analyzes schedule and cost new roofing system & elimination of offset roof

RESOURCES AND TOOLS TO BE USED

- Industry Professionals
- National Roofing Contractors Association - NRCA
- Alexander Personnel
- AE Faculty –Dr. Riley
- Highland Associates – Project Architect and Structural Engineer
- Roofing Manufacturers
- Applicable Literature

EXPECTED OUTCOME

After completing extensive research, comparing several roofing systems, and selecting the best roofing system for the project, it is believed there will be both a cost and schedule savings. It is believed that newer technology in roofing has allowed different types of roofing systems to meet or exceed the durability and sustainability of a cold-applied asphalt roofing system at a lower cost. It is also believed the eliminating the offset will expose the mechanical equipment to a certain degree, but will be minimal and that the cost savings associated with offsetting the roof are worth exposing the mechanical equipment.

ANALYSIS 3: SCHEDULE ACCELERATION OF EXTERIOR ENCLOSUE

PROBLEM IDENTIFICATION

Due to the five week schedule delay with the installation of micropiles, the exterior enclosure (particularly wall framing and sheathing) became a more critical to meeting the projects schedule. Exterior walls are comprised of both CMU's and metal studs with DensGlass sheathing. Finishes on the exterior walls include both Centria insulated metal panels and Arriscraft masonry veneer. Completion of the exterior walls (at least sheathing) must be completed prior to installation of the roof. Interior finishes cannot start until the roof is completed. Progression of work on the exterior shows only one wall being completed at a time and follows the following order of East wall →North wall → South Wall → West Wall.

RESEARCH GOAL

The goal of this research is research determine a cost effective method to accelerate the schedule of the exterior enclosure without changing the design of the exterior envelope.

METHODOLOGY

- Analyze site layout plan to determine if there is ample room work on two separate elevations simultaneously
- Analyze production rates and determine areas for potential increase
- Review specified materials and look for alternatives
- Analyze availability of local workforce
- Compare several possible acceleration scenarios
- Analyzes schedule and cost impacts of acceleration techniques

RESOURCES AND TOOLS TO BE USED

- Industry Professionals
- Alexander Personnel
- AE Faculty
- Highland Associates – Project Architect and Structural Engineer
- Manufacturers
- Subcontractors on project
- Applicable Literature

EXPECTED OUTCOME

Through research and analysis, it is expected that in order to accelerate the exterior enclosure of the building while maintaining the same design will result in a cost increase. However this increase may be worth pursuing if a significant time savings in schedule is discovered. It is believed that there is ample room onsite for work to occur on two different elevations simultaneously without over congesting the site and that the availability of a local workforce will not be an issue.

ANALYSIS 4: DESIGN STUDY TO MAKE PENN STATE'S FIRST NET-ZERO ENERGY BUILDING THROUGH THE USE OF PHOTOVOLTAIC'S

PROBLEM IDENTIFICATION

Currently the Support Services Building project is slated to achieve Penn State's LEED requirement of a LEED Certification rating upon completion. However, the project has utilized very few sustainable techniques that could provide financial benefits to Hershey Medical Center because the Penn State's LEED standards don't push project teams to pursue higher ratings. Features such as photovoltaic roof panels, or a solar hot water heater could be very beneficial to HMC to offset the operating costs of the building. Unlike most buildings on the medical centers campus, the Support Services Building will generate no income to offset operating costs.

Although Penn State conducts research into net-zero buildings, none of their actual buildings are net-zero buildings. Most research is conducted on a small scale, or on projects outside of Penn State. The Support Services Building provides an ample platform for Penn State to develop their first net-zero building and set an example for other major universities to follow.

RESEARCH GOAL

The goal of this research is to design a preliminary PV energy system capable of creating enough energy for the Support Services Building to become Penn State's first "Net-Zero" building.

METHODOLOGY

- Analyze building electrical and mechanical load requirements
- Research PV panel technology and sustainable design techniques
- Contact PV manufactures for design consultation
- Determine # of panels to produce enough kWh required operate facility
- Determine proper placement of panel array on rooftop to maximize energy projection
- Analyze buildings structure to support weight of panels
- Analyzes cost to make "Net Zero"

RESOURCES AND TOOLS TO BE USED

- Industry Professionals
- Alexander Personnel
- AE Faculty – Structural, Electrical, & Dr. Riley
- Highland Associates – Project Architect and Structural Engineer
- PV Manufacturers
- Subcontractors on project
- Applicable Literature

EXPECTED OUTCOME

Through research and analysis, it is expected that in order to make the Support Services Building Penn State's first "Net-Zero" building will result in a significant cost increase. However because the Support Services Building is relatively small when compared to other Penn State facilities, it will provide Penn State the opportunity on a larger scale to research the energy savings and operating techniques of a net-zero building. This would allow Penn State to research and develop ways to incorporate this technology into all of their new projects. It would be model for future sustainable buildings for Penn State. It would also put them on the map as the first university with a Net-Zero energy building.

ANALYSIS WEIGHT MATRIX

In order to depict how each analysis will account for the four main core areas of investigation, a weight matrix (show below in table 1) was developed. Each percentage represents the amount of time and effort that will allocated for each core area of investigation within each analysis.

ANALYSIS DESCRIPTION	RESEARCH	VALUE ENGINEERING	CONSTRUCTABILITY REVIEW	SCHEDULE REDUCTION	TOTAL
Re-design of Foundation System		10%	15%	10%	**35%**
Offset Roof & Roofing Material	5%	10%	5%	5%	**25%**
Exterior Enclosure			5%	10%	**15%**
Net Zero & PV System	25%				**25%**
TOTAL	**30%**	**20%**	**25%**	**25%**	**100%**

Table 1: Weight Matrix of Core Areas of Investigation

TIMETABLE

In order to stay on task and develop a plan for the spring semester, a preliminary timetable has been developed in order to show the work progression for each analysis. This tool will enable both the AE faculty and myself to track my progress and degree of completion of my thesis project. See Appendix B for the spring semester timetable.

CONCLUSIONS

Although Penn State Milton S. Hershey Medical Center's Support Services Building is on track to be another successful project for the university, it is the goal of this thesis to improve on the overall outcome of the project. Through an in-depth analysis and thorough investigations it is believed that a re-design of the foundation system will provide a cost effective alternative to the micropile foundation system utilized on the project. It is also believed that the selection of an alternative roofing system would have saved both time and money, and that eliminating the offset roof would have a minimal effect on the overall appearance of the building. Finally, it is a goal of this thesis to research and develop more sustainable techniques using photovoltaic's in order turn the Support Services Building into Penn State's first "Net-Zero" energy building. To make the building a net-zero building will ultimately increase the cost of the project, but it is believed that the Support Services Building is the perfect platform for Penn State to take their sustainability to the next level.

This proposal is intended to be a working submission with revisions expected based on feedback from the AE faculty and thesis consultants.

APPENDIX A – Breadth Topics

BREADTH TOPICS

In order to fulfill the AE Department's senior thesis requirements the following topics (identified below) will take a closer look into the other disciplines within the AE program that I have studied over the past four years.

STRUCTURAL BREADTH: ***Contributes to Technical Analysis 1 and 3***

Re-designing the foundation system of the Support Services Building from a micropile foundation system to a different system will require the understanding of the column loads, lateral bracing, load transfer to the earth, and settlement requirements. A re-design may include some means of soil improvement. Elimination of the battered piles will result in a change in the lateral stability of structure. Shear walls may need to be added in order to provide lateral stability for the building. Eliminating the micropiles will also alter the pile caps to larger spread footings and could possibly be utilized in conjunction with a structural slab on grade.

The addition of a photovoltaic array to the roof as proposed in technical analysis 3 will require a structural analysis in order to determine loading conditions and support conditions of the roof members and columns.

RENEWABLE ENERGY/ELECTRICAL/MECHANICAL BREADTH: ***Contributes to Technical Analysis 3***

In order to design a preliminary photovoltaic array to make the Support Services Building Penn State's first net-zero energy building will require an understanding of the electrical loads/requirements of the building. It will also require an understanding of the heating/cooling loads in order to determine the amount of energy required to heat/cool the building. Incorporating technology such as solar hot water heaters and possibly a geothermal system will help add to the net-zero effect of the building. It will also require replacing/altering the gas-fired mechanical equipment to accept hot water and/or electric power heat/cool the air.

APPENDIX B – Preliminary Spring Semester Timetable

PROPOSED THESIS SEMESTER SCHEDULE

JANUARY 2011 - APRIL 2011