Proposal

Preliminary Proposal for Spring 2011 Project

Steelstacks Preforming Arts Center

Bethlehem, Pa

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Executive Summary

Steelstacks is a four story, 67,000 square foot performing arts center that is designed to be the signature center for the Artsquest organization. This multi-purpose venue contains two cinemas, a nightclub/café, banquet facilities, a full kitchen along with several concession stands, bars, an open common area and an outdoor patio system. The building north façade is completely glass, which allows for beautiful views of the existing blast furnaces from the former Bethlehem Steel plant. While having a full glass façade enhances the architecture of the building, it greatly alters the mechanical design considerations for the building. With LEED in mind, great measures were gone through to assure that this building was designed efficiently and in a sustainable manner.

To condition the spaces in the Steelstacks building, rooftop units were used to condition most of the spaces. Separate units were used to condition all the major spaces, so they can accommodate the varying activities going on in the building.

The object of this proposal is to adjust the current design of the building to minimize energy consumption and make the building less expensive to operate. This will accomplish many different tasks for the Steelstacks including reducing the building footprint. There are a few alternative systems that could accomplish this: Ground Source Heat Pumps, Solar energy, as well as Thermal Energy Storage.

The implementation one of these systems will be a very difficult task. It will require a building integration within the building systems. The feasibility of each of these systems will be evaluated and the best option will be chosen based on the criteria of reducing energy consumption and reducing operating cost.

Different approaches will be used to analyze these systems. Software programs include Trane Trace, Carrier HAP, Microsoft Excel, Engineering Equation Software, and some type of geothermal software.

Existing Mechanical Equipment

Design Objectives and Requirements

The Steelstacks building was designed with a few main objectives in mind. The first of which was to design an energy efficient building that met LEED certification with a very structured budget. As well as achieving some type of LEED certification, the designers also need to meet all ASHRAE Standards that were applicable. From this the building had to meet energy, ventilation, temperature, and humidity requirements. While having these in mind, the design that became the most logical to use was having each major zone of the building to have its own air-handling with energy recovery units on areas which have high occupancy densities.

Site and Budget

The Steelstacks is on a very unique site which affected everything from the architecture to the mechanical systems. It is located on what was previously the Bethlehem Steel plant from the late 1800's till about 2001. In an effort to minimize the economic impact the closing had on the Lehigh Valley, a plan was made to revitalize the south side of Bethlehem. A major redevelopment has ensued with the addition of a casino, hotel, and Museum of Industrial History. The revitalizing continued when the concept of Steelstacks emerged. Along with this performing arts center there are plans for outdoor amphitheater and community centers. In the years to come this site plans on hosting Musikfest, which is an annual festival held in Bethlehem that brings thousands of visitors from across the country. The site had great effects on the architecture of the building, a slab to roof window is placed on the north wall of the building to give views of the Blast Furnaces, and steel beams are exposed as well mechanical ductwork as homage to the original site.

Equipment Summaries

The Steelstacks building utilizes a fairly simple conditioning system. It consists of six rooftop units (RTUs) that serve almost the entire building. Each of these systems serves a very specific area; this is done so that the building can be controlled according to what type of event is going on. There is also one Air Handling Units (AHU) that serves exclusively the Blast Furnace Room. The

Blast Furnace Room is the one of the highlight areas of this building; it is a multipurpose room that can host events from concerts to banquets.

	Supply Air(CFM)	Supply Fan Power(HP)	Exhaust Fan Power (HP)	Enthalpy Wheel Power (HP)	Cooling Coil Cap (MBH)	Gas Fired Cap (MBH)
RTU-1	6800	5	-	-	191.1	199
RTU-2	1650	1	-	1.18	39.9	52.5
RTU-3	3020	2	-	3.62	79.3	126.7
RTU-4	23485	25	-	7.24	457.4	117.5
RTU-5	17500	20	10	10.86	443.3	790
RTU-6	3000	1.5	0.5	-	113.4	126.7
AHU-1	5300	7.5	0	-	291.2	378.8

RTU-1- This unit serves the kitchen area on the third floor and the areas relating to this area such as storage areas.

RTU-2- This unit serves exclusively the Small Cinema on the first floor.

RTU-3- This unit serves the Large Cinema on the first floor

RTU-4- This unit serves the Creative Commons area, this area has portions of it that are two stories high. The Creative Commons is an area for people to gather, it boast views of the blast furnaces as well as sitting areas and places to relax

RTU-5- This unit serves the Musikfest Café that is on the third floor and is two floors high. It also serves the mezzanine level that overlooks the Café. This area will hold concerts and musical events, with the VIP area located on the Mezzanine as well as bar. This area also overlooks the blast furnaces to the north.

RTU-6- This unit is the most diverse unit, it serves most of the remaining space in the building that require conditioned air. Areas include offices, retail areas, corridors, green room, and some storage areas.

AHU-1- This unit is used to condition the Blast Furnace room.

Enthalpy wheel-There is a total of four enthalpy wheels associated with the conditioning systems

for the Steelstacks building. The wheels are placed on systems that serve areas with high population density. This is because these areas require a high ventilation rate. So an enthalpy wheel is can recoup some of the energy that would otherwise be thrown back into the environment.

The natural gas boilers are located on the fourth floor of the building in the mechanical room. It is a Lochinvar Intelli-Fin system with 89.9% steady state combustion efficiency. This boiler provides hot water to AHU-1, which is the indoor only indoor unit (all others are roof top packaged units boilers included). In addition to the supplying this one air handling unit it also provides hot water to the terminal unit hot water re-heat boxes located in the smaller rooms throughout the building.(offices, green rooms ect.)

Mechanical System Evaluation

Overall, the mechanical system of the Steelstacks building is a very well designed system. The system is very simple and yet very effective for this building. The ability for the system to regulate itself based on the various activities within the building creates a very efficient building. This allows for the building to effectively run at approximately same efficiency with no dependency of the amount of people or events going on in the building.

The building envelope was one of the primary considerations when designing this building. Even with a large amount of windows on the south wall of the building, the envelope was designed to exceed ASHRAE Standards; these results can be seen in Technical Report 1.

The construction cost of the mechanical system is about 9% of the building total cost. This is a somewhat low value for this type of building. This can be attributed to the ease of access to the rooftop units as well as most of the ductwork is left exposed which leaves for easier installation.

The operating cost of the Steelstacks Building is somewhat high; this could be for a couple of things. The calculated cost of operating the building was $4.63/ft2 annually. The use of the building leads to high cost, because of late night activities which call for lots of lighting as well as

condition of the air in coldest parts of the day. Another reason the calculated cost could be high is the validity of cost of energy. The cost was estimated from researched values and is not exact to this specific building.

One finding that deemed itself to be very interesting was the amount of sensors placed throughout the inside and outside of the building. These were then sent to the main control system to evaluated different criteria so that the building would run most efficiently. Sensors capacity ranged from temperature to CO2, to humidity.

Proposed Alternative Systems

The current mechanical system is designed with efficiency in mind. A LEED certification will be awarded once the building is complete. Even with this amount of detail placed on the mechanical design there are still a few areas which could reduce the costs of the building. The objective of these alternative solutions is to increase the overall efficiency of the building. These alternative designs should be able to integrate into the design of the Steelstacks building. The following alternatives will be discussed in this report: Ground Source Heat Pumps, Solar Energy sources, as well as Thermal Energy Storage

Ground-Source Heat Pumps

The Steelstacks building is located on the redevelopment site of the former Bethlehem Steel Plant. This large campus is the future of many new building. The Steelstacks is one of the first buildings on this site, making its choice of lot and surrounding buildings comes at their discretion. Their lot has enough room to accommodate a ground source heat pump system for this building. The GSHP would provide a considerable amount of energy savings because the earth temperature is constant (~52^{o}F Bethlehem).

A limiting factor that will need to be explored in more detail is the existing conditions below the earth. Since this site was previously part of a major operation, the possibility of underground tunnels and large concrete slabs are possible. At the start of the redevelopment project,

underground tunnels were found as well as slabs reach upwards of 3 feet deep were found that were unidentified on any previous documents. This will definitely have to be looked into in greater detail for feasibility.

A ground source heat pump system would have a high initial cost due to the boring out of the earth, but they have considerably low maintenance cost as well very long system life. There are other factors that will need to be looked into for GSHP system; the timetable for construction could be altered if the boring of holes could not be done simultaneously with the early construction of the building.

The final design of the GSHP system will drastically reduce the load of the building but the traditional payback period of a system like this will have to be looked into because of the limiting factors. The overall mechanical system would also need to be altered in order to use this system, packaged units would need to be altered to a centralized chiller and boiler plant. All of this will be compared and analyzed for this system.

Solar energy

Solar energy has always been something that has interested me throughout my college career. I feel that this is the perfect opportunity to explore to depths that I have never gone. The Steelstacks building leads itself to be a great site for solar energy. There are no relative obstructions of the sun during most of the prime energy hours.

Solar energy will be explored in conjunction with GSHP; these two systems could work very well together for reducing energy of the building. This study would look into the best implementation of the photovoltaic array, as well different storage backups, and tracking.

As well as reducing mechanical load of the building, I am going to look into the financial impact the array will have on the construction cost. This building was done on a very strict budget, but government rebates and any other types of incentives will be looked into to verify if this is a valid solution for the owner.

Thermal Energy Storage

The two previous ideas for reducing the load of the building lead to another solution that will be explored. Thermal energy will be explored to further flatten the loads on the building. It is necessary to try and flatten the loads because this building has varying loads depending on the Steelstacks is accommodating. If the loads could be flattened and this would not only reduce energy consumption but drastically reduce the energy bill due to on and off peak rates.

Thermal energy works by running equipment on off peak hours and storing the energy in either ice or chilled water. Then when then energy is needed during the day it takes from the stored energy. Another advantage to be explored in thermal storage is that the chiller can work at a better efficiency due to the constant load to chill the water. This will also reduce the size of the chiller needed for this system. This will help on cost of the mechanical system.

The biggest task in this project for using energy storage will be that packaged units will need to be converted to a chiller. I think that the research will show that it is more efficient to do have the mechanical system run this way. The condensing units that are currently in use have certain inefficiencies because of the varying sizes of all them. One chiller could be used to serve the whole building and then different AHU to serve the different zones that are already used.

These three solutions to reduce the overall building energy consumption will be explored to work seamlessly to drastically reduce the load. These solutions will hopefully completely fatten the loads of the building and create a very efficient building.

Breadth Topics

In addition to the mechanical topics covered in this report, two breadths will be discussed. The breadths will cover other areas of the building for improvements.

Architectural Breadth

An architectural Breadth will be looked into to enhance the Architecture on the north façade. A study will be done to determine if the there is a way to reduce the summer loads on this large

window wall without losing the fundamental architecture of the building. Different material will be looked into for allowing light to be emitted still but not the entire thermal load. Building orientation will also be looked into as well.

Acoustical Breadth

The Steelstacks building is a performing art center, so acoustical consideration are very important to the success of the building. Many studies were done to have effect acoustical rooms and very efficient transmission loss between rooms. I would like to look into the effects of the rooftop units and the vibration they well transmit into the building. The original design had a system to eliminate any vibration going into the structure of the building. But a combination of money and miscommunication consideration did not allow for them to be installed. The large units were placed on thickened slabs of concrete and that is all. A closer look into this will allow me to see if any noise will transfer to the rooms below it and have a negative effect on the Musikfest Café.

Tools and Methods

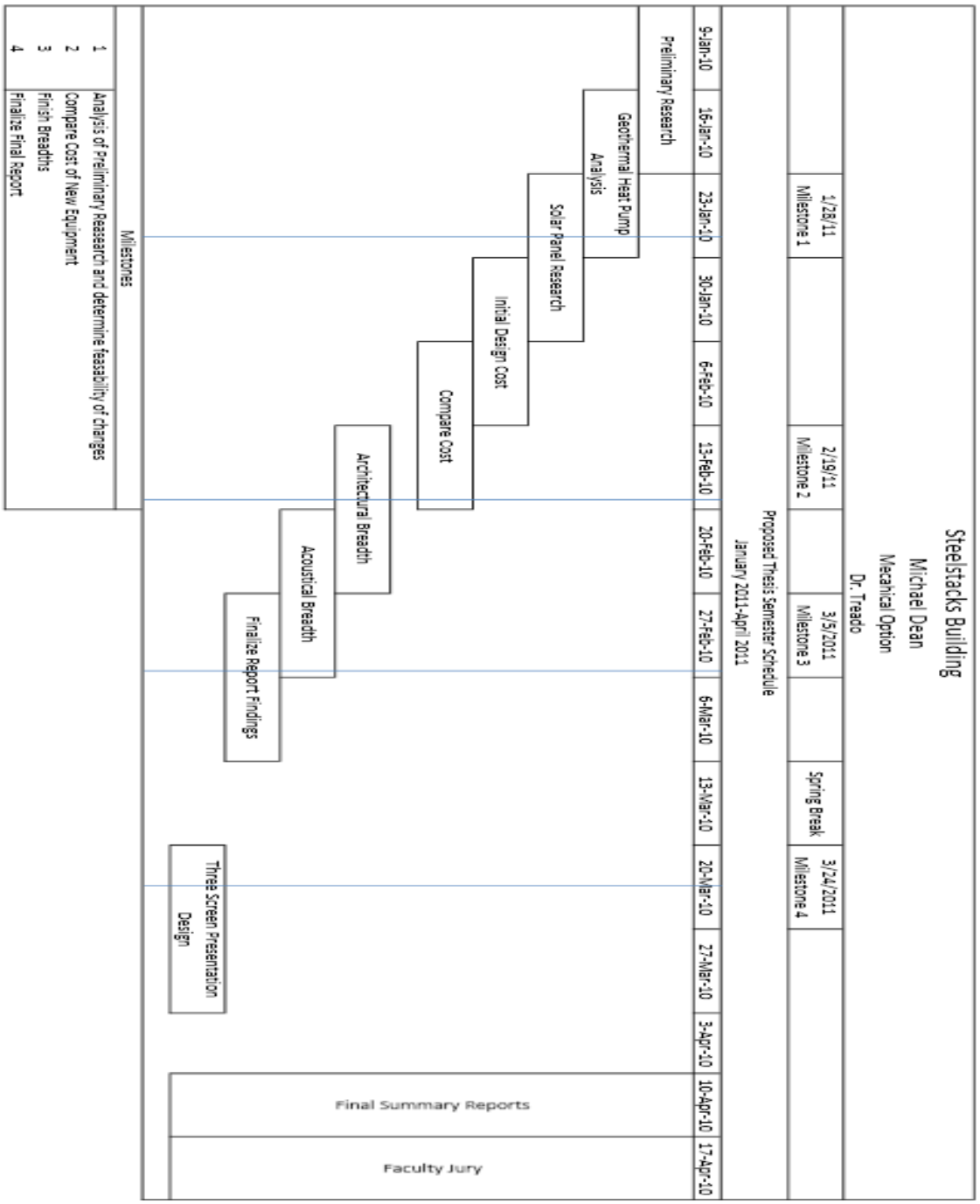
I plan to conduct research on the above-mentioned topics using a different computer programs such as Trane Trace, Carrier HAP, Microsoft Excel, Engineering Equation Software, and some type of Geothermal software. Both modeling software packages have some type of alternative modeling capabilities. These will need to be looked into in more detail to decide which one is the best choice.

Microsoft Excel will be using in and multiple situations to solve and assist on problem solving. Excel is also very effective at conveying information over graphical figure which will be very beneficial.

Energy Equation Solver is another program that has a myriad of potential, and will be very effective in solving difficult problems. Although I am still in the learning stages of all the power of EES, I think that it will prove to be education to learn another useful program.

There are a few modeling software packages that can be used for designing GSHP. I will have to do more research into each program along with contacting industry professionals to decide which will be the best to use in this situation. These packages will allow me to try different lengths and numbers of GSHP wells to better identify which will be the best use.

Schedule


Steelstacks Building
Michael Dean
Mechanical Option
Dr. Treado
Proposed Thesis Semester Schedule
January 2011-April 2011
1/28/11 Milestone 1
2/19/11 Milestone 2
3/5/2011 Milestone 3
Spring Break
3/24/2011 Milestone 4
9-Jan-10
16-Jan-10
23-Jan-10
30-Jan-10
6-Feb-10
13-Feb-10
20-Feb-10
27-Feb-10
6-Mar-10
13-Mar-10
20-Mar-10
27-Mar-10
3-Apr-10
10-Apr-10
17-Apr-10
Preliminary Research
Geothermal Heat Pump Analysis
Solar Panel Research
Initial Design Cost
Compare Cost
Architectural Breadth
Acoustical Breadth
Finalize Report Findings
Three Screen Presentation Design
Final Summary Reports
Faculty Jury
Milestones
1 Analysis of Preliminary Reasearch and determine feasability of changes
2 Compare Cost of New Equipment
3 Finish Breadths
4 Finalize Final Report

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