PSUAE

MECHANICAL PROJECT PROPOSAL (Revised)

REDESIGN PROJECT

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2011

Mechanical Option-IP

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Executive Summary

The main objective of this report is to summarize the information gathered from previous Technical reports, propose new design considerations and layout a tentative schedule of work of the spring 2011 semester. The Sunshine Elementary School design has been analyzed throughout the fall 2010 semester. The findings of the research and analysis have led to ideas of possible energy savings which will be investigated.

The first part of the redesign proposal will focus on changing the water-to-air heat pump system to a water-to-water heat pump system thus reducing energy usage by inefficient fans and replacing with highly efficient pumps. The redesign is to include radiant floor heating and cooling for all areas of the Sunshine Elementary School where small heat pumps were originally utilized. The larger areas, where the load was designed to be handled by larger AHU's, will not be redesigned due to quick loading issues. The ventilation of the proposed redesign will utilize a centralized DOAS system with larger more efficient fans.

The second part of the proposal is to install BIPV's in attempt to create a net-zero heating and cooling system. This will include a redesign of the complicated roof structure to a more simplistic gable roof along with rotating the building to face due south. This will allow for photovoltaic shingles to be installed on the entire south facing roof. The solar array will be grid tied and attempt to, at the least, offset the energy used by the pumps, fans and condensers of the mechanical system.

The breadth of the proposal will be in the structural and construction impacts of proposed changes. The structural impacts of a radiant floor system will be investigated along with the impact on constructability of the new roof structure. The construction impacts of both these changes will also be investigated. This will include scheduling changes, staging and cost analysis of the proposed design.

The requirement of the integrated program to utilize my Master's course work will be done in the third part of the proposal. A solar thermal collection system will also be added to the design. This is for domestic hot water. This will utilize information I have learned in Dr. Treado's 597 Solar Thermal Collection Systems and Design. The system will be sized to have enough capacity to handle the demand of DHW of the Sunshine Elementary School. This is to tie into the above prosed design by furthering the redesigns ability to be a net-zero energy building.

Project Summary

The Sunshine Elementary School went under construction in March of 2010 and is planned to be finished in June 2011. The School is located in the Hershey, PA area. At 103,000 ft^2 the building houses kindergarten through 5th grade students along with faculty. The building includes a gymnasium, large kitchen, cafeteria, classrooms, and large administration area. The project goal is to receive a Silver rating by the Leadership of Environmental and Energy Design (LEED).

The new elementary school is located in a rural area connecting two townships. The building is to be used for both kindergarten and 1st through 5th grade students. Due to this a "school within a school" was a major concept of the design. The youngest of the students will be in the center. This area will function independently as a smaller environment allowing the students to acclimate to the school experience. This area consists of two, single story, eight room class pods with shared spaces and also includes a kitchen area and a multi-purpose room.

The 1st through 5th grade wing is two-story and has an adjacent gymnasium at one end and a multi-purpose room at the other end. This wing connects with the kindergarten center through shared spaces, which include a library, production kitchen, building storage, mechanical and electrical spaces, the nurse suite and building administration.

Existing Mechanical System Summary

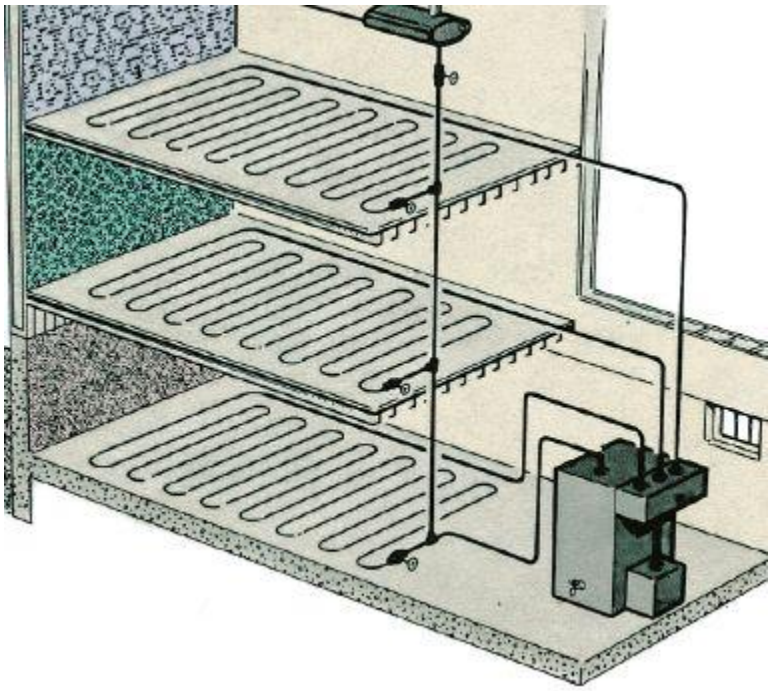
The total cost, given by the project manager, of the MEP system was $5,271,200. The total area of the building was 103,000 ft^2, yielding a cost of $51.17/$ft^2$. This does not include approximate costs of $100,000 for commissioning and $69,100 for air balancing, hydronic balancing and commissioning support.

A highly efficient ground source heat pump system was chosen for the mechanical design. Ninety-two ground wells were designed in order to create the capacity needed. The water loop

is then pumped to small heat pumps severing individual spaces and five larger air handling units serving lager spaces such as the cafeteria and gymnasium. The heat pumps are a water-to-air system. The ventilation is ducted through the corridor to each space and is controlled by demand control ventilation by the way of CO^2 sensors located in each space. To further conserve energy, energy recovery units with variable speed fans are located to exchange temperatures between exhausted air and outdoor air.

Redesign Considerations

The proposed redesign consists of three major parts; Convert the water-to-air heat pump design to a water-to-water design utilizing radiant floor heating and cooling. Increase the ventilation air by 30% of that required by ASHRAE Standards and add daylighting controls to lower the cooling load and increase the learning environment. All of the proposed systems are focus on the classrooms and kindergarten areas.



The conversion from water-to-air system to water-to-water system is to reduce the wasted energy of inefficient small fans within each heat pump unit throughout the entire building. The energy used by efficient pumps is predicted to be much less. Also the Zoning of the heat pumps

is to increase to include banks of classrooms with similar load characteristics. This is expected to incur a larger first cost but will be evaluated through a life cycle cost analysis to prove if it is economically feasible. The area taken by the mechanical system is predicted to be smaller and the noise pollution to the learning environment is predicted to be less. The cost of sheet metal used by ducting in each class room will be saved by the reduction in size due to having to supply air for ventilation only. Also with a dedicated outdoor air ventilation system indoor air quality will improve due to adding 30% more outdoor air. This will not only improve the learning environment but also gain an additional LEED point. It is predicted that the energy consumption due to increased OA will only increase by a small fraction.

Breadth Work

The breadth work of the proposal is within the impact of the proposed redesign. The installation of a radiant floor system will impact construction of the building, being cost, staging and scheduling. The radiant floor is expected increase construction time and decrease constructability. An analysis comparing original designed construction schedule to proposed redesign will be performed. This will include a life cycle cost analysis of both the original design and the redesign. The benefits will be weighed against these impacts.

The second breadth of the work will be an evaluation of added daylighting controls. The analysis will include the energy impacts on the building by reducing the lighting energy added to the loads by using luminaire sensors within each classroom. It will also include a study on the effects of daylighting within the learning environment.

Integrated Program Work

Through the use of resources and knowledge learned Master level class, Indoor Air Quality, an analysis of the effects of increased OA will be done. This will include case studies on the effects of the learning environment and indoor air quality.

Project Methods

Several tools will be utilized to perform the proposed analysis. The evaluation of the in floor radiant heating and cooling system will heavily rely on an eQuest model which will be reconstructed with proposed changes allowing for a direct comparison to original design. The new overall energy consumption will be found by these means. The feasibility of in floor radiant cooling will be analyzed to ensure condensation will not be a concern. All maintenance, operation cost, and troubleshooting of said system will be a part of the analysis. .

Manufactures data on Radiant flooring will be crucial to the analysis of the radiant floor system. Uponor, a producer of said systems, will be a tool throughout the project. All proposed systems will be analyzed through a life cycle cost analysis to investigate economic feasibility.

Prediction

I predict the proposed redesign will incur a large initial first cost, but that a life cycle cost analysis will prove it to be economically feasible. In addition I predict a better learning environment due to the daylight controls and increased OA.

Preliminary Research

The following is a list of resources used in the preliminary research conducted for proposed design. The list of sources will be updated as the analysis is performed and the project progresses. Beyond this list meetings and discussions with a mechanical engineer have helped develop this proposal.

ASHRAE Handbook, HVAC Systems and Equipment. American Society of Heating, Refrigeration, and Air Conditioning Engineers, INC., Atlanta, GA 2004

ASHRAE Handbook, HVAC Fundamentals. American Society of Heating, Refrigeration, and Air Conditioning Engineers, INC., Atlanta, GA 2004

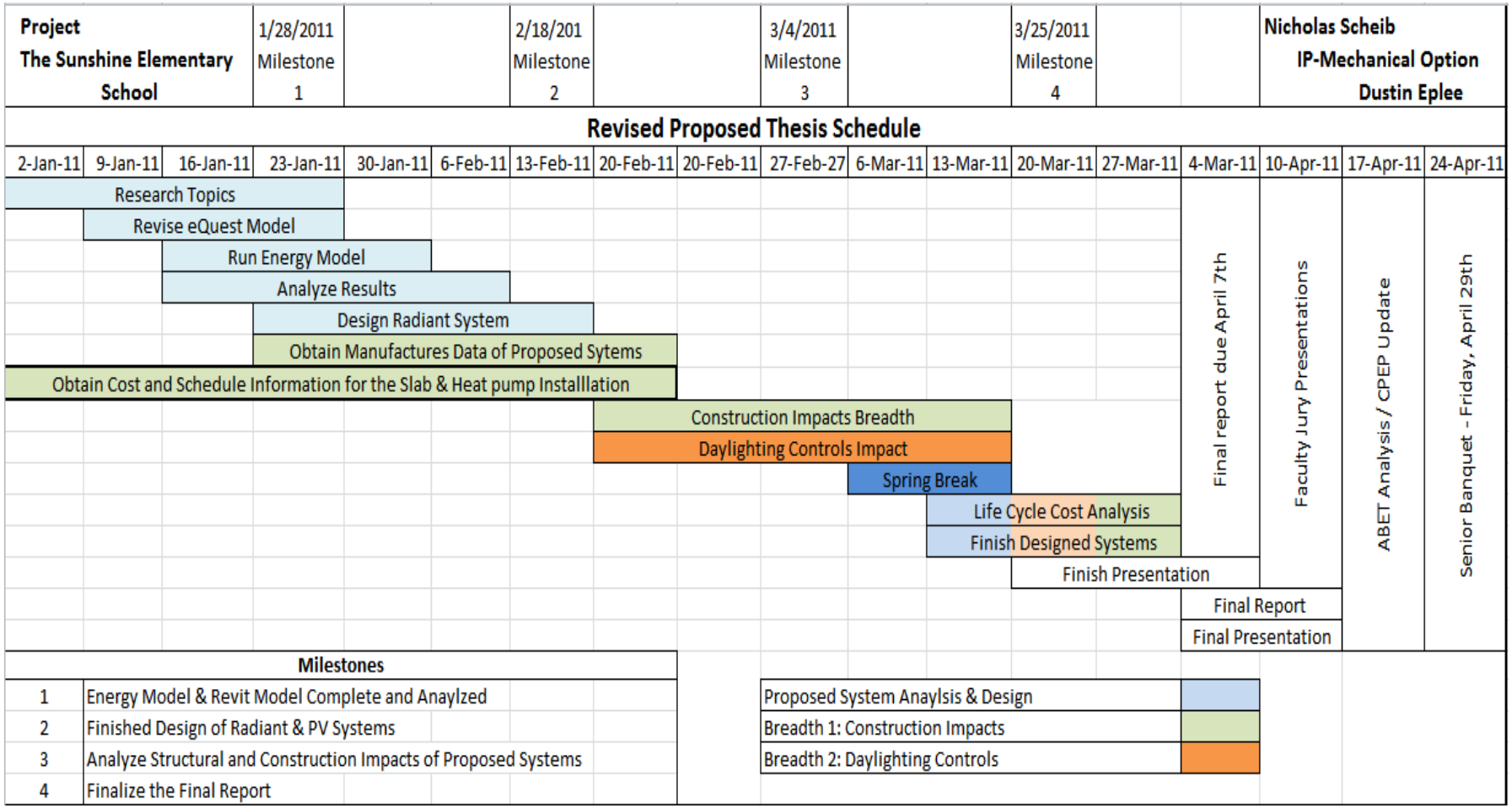
ASHRAE Handbook, HVAC Applications. American Society of Heating, Refrigeration, and Air Conditioning Engineers, INC., Atlanta, GA 2004

Beckman, Duffie (2006), *Solar Engineering of the Thermal Processes*, John Wiley & Sons, Inc.

McQuiston, Parker, Spitler (2005*), Heating, Ventilating, and Air Conditioning*, John Wiley & Sons, Inc.

Tentative Work Schedule

This is only a tentative schedule and will possibly change as the research is performed. All dates are available for adjustment except for the presentation date of 4/07/2010.


Project
The Sunshine Elementary School
1/28/2011 Milestone 1
2/18/201 Milestone 2
3/4/2011 Milestone 3
3/25/2011 Milestone 4
Nicholas Scheib
IP-Mechanical Option
Dustin Eplee
Revised Proposed Thesis Schedule
2-Jan-11
9-Jan-11
16-Jan-11
23-Jan-11
30-Jan-11
6-Feb-11
13-Feb-11
20-Feb-11
20-Feb-11
27-Feb-27
6-Mar-11
13-Mar-11
20-Mar-11
27-Mar-11
4-Mar-11
10-Apr-11
17-Apr-11
24-Apr-11
Research Topics
Revise eQuest Model
Run Energy Model
Analyze Results
Design Radiant System
Obtain Manufactures Data of Proposed Sytems
Obtain Cost and Schedule Information for the Slab & Heat pump Installlation
Construction Impacts Breadth
Daylighting Controls Impact
Spring Break
Life Cycle Cost Analysis
Finish Designed Systems
Finish Presentation
Final Report
Final Presentation
Final report due April 7th
Faculty Jury Presentations
ABET Analysis / CPEP Update
Senior Banquet - Friday, April 29th
Milestones
1 Energy Model & Revit Model Complete and Anaylzed
2 Finished Design of Radiant & PV Systems
3 Analyze Structural and Construction Impacts of Proposed Systems
4 Finalize the Final Report
Proposed System Anaylsis & Design
Breadth 1: Construction Impacts
Breadth 2: Daylighting Controls