Thesis Proposal

Rendering Courtesy Moody·Nolan, Inc.

George W. Hays PK-8

Cincinnati Public School

Cincinnati, OH

Prepared For
Dr. William Bahnfleth

By

Rodrick A. Crousey
The Pennsylvania State University
Architectural Engineering
Mechanical Option
January 29, 2006

Table of Contents

Executive Summary

This proposal considers variations to the design George W. Hays PK-8 Public School in Cincinnati, OH. These variations are related to a major mechanical system change which will then be analyzed during the spring semester of 2007 using various programs, including existing programs such as Carriers Hourly Analysis Program. The success of the proposed idea will be determined in comparison to the original design with respect to building cost, building aesthetics, the affect on the occupants of the building and the buildings affect on the community around it.

The proposal is for an ice storage system in coordination with a chiller to replace the existing 170 ton chiller. This proposal will naturally bring complications in the structural design of the building along with complications in the construction of the building. Multiple structural and construction options will be looked at. By reducing the electrical demand charge, the ice storage system has the potential of achieving a lower life cycle cost and building opperation then the initially designed system.

The preliminary research for the proposals is also highlighted in this report along with a proposed semester calendar for the fall semester of 2007. This calendar displays dated goals for achieving the major milestones for this project.

1. Building Background

The George W. Hays PK-8 public school is located in Cincinnati, OH and owned by the Cincinnati Public Schools. The three story building is a total of 66,000 ft^2 with a footprint of 3,500 ft^2. Construction began on April 24, 2006 and is expected to be completed in September of 2007. The total construction cost for the building is $11,149,324.

The building thermal loads are met by three main Air Handling Units (AHU) with supply airflows of 22,000; 18,000; & 12,000 cfm. As part of energy conscious design, each AHU contains a complete enthalpy wheel. The systems are all single duct or series fan powered terminal devices with local hot water reheat and plenum return. Zones requiring special consideration have local heating or cooling to achieve an adequate thermal comfort. The largest of these sub systems is a 1280 MBH radiant panel serving the reception area. All cooling and heating loads are met by a single 170 ton air cooled chiller and two 1500 MBH natural gas boilers. Special spaces in the building include a 6,048 ft^2 gymnasium and a cafeteria and cafeteria accessories for 500 students.

2. Critique

Generally, the mechanical system design obtains the initial goals of the project team. Though no building is designed to an optimal standard, this building does deliver the necessary components to fulfill the owner’s expectations.

To ensure reduced energy use in the building, the mechanical designers implemented a sophisticated control system to minimize wasted energy. They also implemented three complete energy wheels to recover both latent and sensible energy from the exhaust air. However, the energy consumption using only one chiller may be significantly higher then using two staged chillers. This is because, generally speaking, the maximum efficiency point of a chiller is at full capacity. The load profiles of a chiller express that typical chiller usage is weighted towards the bottom half of its capacity and only achieves full load capacity a few hours each year. By strategically staging multiple chillers the designer may be able to run each chiller closer to design capacity, resulting in an increased overall efficiency. However, an extra chiller would also increase initial costs and increase the amount of space required for the mechanical equipment. It is likely that the designer chose to sacrifice reduced energy consumption because of a mixture of these two reasons.

Thermal comfort was executed in the design by implementing a complicated controls sequence to control indoor air temperature and humidity. The controls system helps to ensure comfortable living conditions at all times in the space, including the early hours of occupancy by a startup period that adjusts as the response characteristics of the building are learned. By research and experience, the designer was able to make predictions about the loads in the building. They also implemented special controls in areas that previous experience had shown a difficulty in maintaining thermal comfort. The primary example of this is the radiant panel in the reception area with local thermostat control. However, as a VAV system, the building naturally lends it self to the possibility of poor humidity control.

The building controls are also effective in maintaining adequate amounts of OA to each of the spaces. Though the design minimum OA does seem to be bellow that required by ASHRAE 62.1, it does meet with code and was determined to meet the design goals by the design team. However, VAV systems run a high risk of over ventilation which can result in wasted energy.

The mechanical team was also successful in confining the mechanical equipment area to a level that was acceptable to the owner and architect. Though initial mechanical room areas were exceeded, the mechanical designer worked with the architect and owner effectively to ensure the expectations for the building were met. These changes required the addition of two mechanical mezzanines, which drastically affected the exterior design of the building. However, the architect was able to work with these adjustments and was pleased with the final outcome of the building. The amount of space the mechanical equipment occupies is always a concern in a project, however in this project was fortunate enough to have the ability of extending the mechanical space and adjusting the architecture of the building.

3. Proposed Redesign Ideas

All proposed redesign ideas will be analyzed in comparison to the current building design with respect to cost, building aesthetics (visual and acoustical), the affect on the occupants of the building and the buildings affect on the community around it. The proposals were decided based upon the possibility of a better design as defined above and the perceived educational value of particular topics.

3.1 Alternatives Considered

Several proposals for the school were considered. However, some of the ideas were rejected from not being viable or not presenting the same educational value that the selected proposals offered. A radiant heating and cooling system for the gymnasium was considered. However, this idea was rejected because the VAV system serving the gymnasium is a 100% OA system. Other considerations included thermal storage systems not requiring the production of ice. These would allow the chiller to produce warm solutions in exchange for larger storage compartments. These systems are typically reserved for much larger applications and were thereby thrown out as valid possibilities.

3.2 Mechanical Components

The redesign idea for the mechanical components of the building is the introduction of latent storage in the form of ice storage.

Three main components of ice storage will be looked into thoroughly: proper selection, proper controls methodology, and proper simulation. The ice storage system lends itself to the Hays School because of the low cooling load during off-peak hours. Distributing cooling energy into the nighttime hours should reduce the electric bill by lowering the peak demand usage. In addition to lowering costs, this will also lower the demand required for the city power, providing a service that will benefit the community as a whole. The ice storage system will have two expected draw backs: increased mechanical space and complications with low supply temperatures from the chiller. The selection will most likely be selected by the design day and not a weekly sizing cycle because of the amount of extra space that would be used by a weekly sizing cycle. The design day data will be gathered from a Trane Trace file. This data will then be used to look at designing the system based off of full storage, load leveling partial storage, or demand limiting. For

demand limiting the electrical data of the Trace file will also be extracted to determine how the storage system should discharge to minimize the electrical demand charge. Depending on the method used to select the size of the ice storage system an appropriate method of controls will be chosen. A life cycle cost analysis with ice storage will then be compared with a life cycle cost analysis of a system not using ice storage to determine the validity of the proposal.

3.3 Breadth Components

The ice storage system will have a direct impact on the electrical components of the building. An ice storage system is most likely to save money by shifting the chillers electrical usage to nighttime. This shift will have a considerable affect on the sizing of the electrical equipment in the building.

The location of the tanks must also be looked at with respect to mechanical function ability, aesthetic function ability, and occupant cautions. The proper structural requirements of this will also be researched and decided upon.

4. Preliminary Research

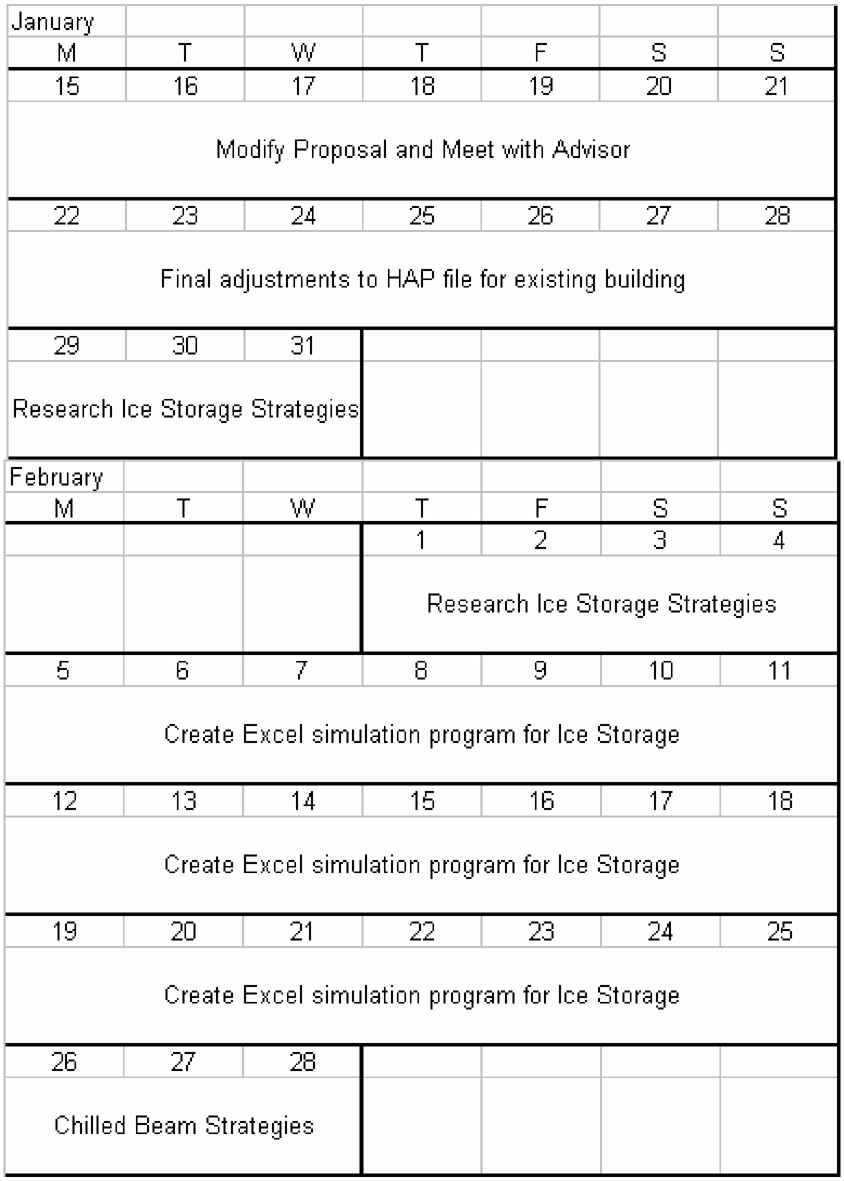
Preliminary research for the proposals includes coursework and articles in professional journals. Primary coursework applicable to the chilled beams portion of the project is derived from Optimization of Systems with Dr. Mumma taken in the Fall of 2006.

Central Cooling Systems taught by Dr. Bahnfleth in the fall semester of 2006 served as an aid to preliminary research regarding the ice storage proposal. Three professional articles also served in researching ice storage. "A History of Comfort Cooling Using Ice," published in February 1999 in the *ASHRAE Journal* and written by Bernard Nagengast, presented a history of the use of ice storage and a quick overview of the various applications ice storage has seen. "Thermal Energy Storage Myths," written by Mark MacCracken was published in September 2003 to the *ASHRAE Journal*, rebutted various common concerns related to thermal storage systems. The final article used for preliminary research named, "Cool Thermal Storage: Is it Still Cool?" was written by Dr. Bahnfleth and published in HPAC Engineering in April 2002.

5. Calendar

Table 5.1 shows the planned calendar for the spring 2007 semester. The calendar includes preparation and research along with the planned dates for execution and the compilation of the final thesis presentation. Because a final thesis advisor is not known, specific meetings with faculty are not shown on the calendar.

Table 5.1



January						
M	T	W	T	F	S	S
15	16	17	18	19	20	21
Modify Proposal and Meet with Advisor						
22	23	24	25	26	27	28
Final adjustments to HAP file for existing building						
29	30	31				
Research Ice Storage Strategies						

February						
M	T	W	T	F	S	S
			1	2	3	4
			Research Ice Storage Strategies			
5	6	7	8	9	10	11
Create Excel simulation program for Ice Storage						
12	13	14	15	16	17	18
Create Excel simulation program for Ice Storage						
19	20	21	22	23	24	25
Create Excel simulation program for Ice Storage						
26	27	28				
Chilled Beam Strategies						

Table 5.1 (Cont'd)

March						
M	T	W	T	F	S	S
			1	2	3	4
			Research Chilled Beam Strategies			
5	6	7	8	9	10	11
Create Excel simulation program for Chilled Beam						
12	13	14	15	16	17	18
Create Excel simulation program for Chilled Beam						
19	20	21	22	23	24	25
Finish Breadths						
26	27	28	29	30	31	
Compilation of Report						
April						
M	T	W	T	F	S	S
						1
						Comp...
2	3	4	5	6	7	8
Compilation of Presentation						
9	10	11	12	13	14	15
Compilation of Presentation						
16	17	18	19	20	21	22
Presentation						

Compilation Progress Calendar for spring 2007 Final Thesis Project.