WORCESTER NORTH HIGH SCHOOL

THESIS PROPOSAL v2 :: **ADAM TRUMBOUR** :: CONSTRUCTION MANAGEMENT

ADVISOR: DR. MAGENT :: JANUARY 14, 2010

CONTENTS

EXECUTIVE SUMMARY

This is the final portion of the fall 2009 thesis study on Worcester North High School, setting the ground for research and analysis during the spring of 2010. What follows outlines the intents and methods of my research.

There are four areas of focus: a comparison study of the Massachusetts Cooperative for High Performance Schools (MA CHPS), the design and implementation of a solar photo-voltaic system given a certain budget, the design of a green roof and the according structural changes required and finally the redesign and acceleration of the lighting system while increasing its efficiency.

The MA CHPS study aims at evaluating the current rating system. It will define areas that could be improved, as well as how the CHPS program has been implemented on the WNHS project. Additionally, the CHPS program will be contrasted with LEED to help locate it strengths, weaknesses and specificities that make it better for schools.

The solar PV design involves researching and designing a viable PV system given the $250,000 allowance in the project budget. Along with the design portion will be a study to establish the benefits and effects of installing a PV system, hoping ultimately to give the owner legitimate reasons to install the system.

A green roof design analysis follows a similar motivation as the PV system. Researching available technologies will aid in creating a viable design. A major aspect of the design will include an evaluation of the structural system, redesigning a typical bay in order to support the green roof loads.

Last, focusing on the lighting system is intended to render it more efficient thus reducing its energy consumption and carbon footprint. As a construction management study, the schedule will be accelerated 10-15% and the effects on cost will be determined.

Update: Due to lack of available project information, the schedule acceleration study has been removed. This study will focus on the implementation of LED luminaires.

TECHNICAL ANALYSIS 1: MASSACHUSETTS CHPS STUDY

In February 2009, the U.S. government passed the American Recovery and Reinvestment Act of 2009. This plan includes an investment of $61.3 billion in the energy sector, including the weatherization of current buildings, the development of renewable energy, and energy efficiency projects for buildings[1]. With rising energy costs and an increased awareness of society's impact on the planet, the importance of designing an energy efficient building has never been greater. At the PACE 2009 Roundtable, Energy and The Building Industry was one of three topics of discussion, further indicating the relevance and importance of energy efficiency in buildings. Currently, the construction industry is faced with meeting the physical needs motivating design as well as the building's impact on the environment. To provide a design metric, several programs exist, with LEED being the most prominent. There are other programs, too, that were created to cater specific building types and locations.

The Massachusetts Cooperative for High Performance Schools (MA CHPS) is a program designed to increase the efficiency and sustainability of school buildings and is part of a larger CHPS program that governs several state members. It functions as a rating system alternative to a LEED certification, focusing on the context of healthy schools for children and adults. In order to address this apparent critical industry issue, I will perform a study on the MA CHPS program, investigating its intents, requirements, applications and the positive and negative aspects of following the program.

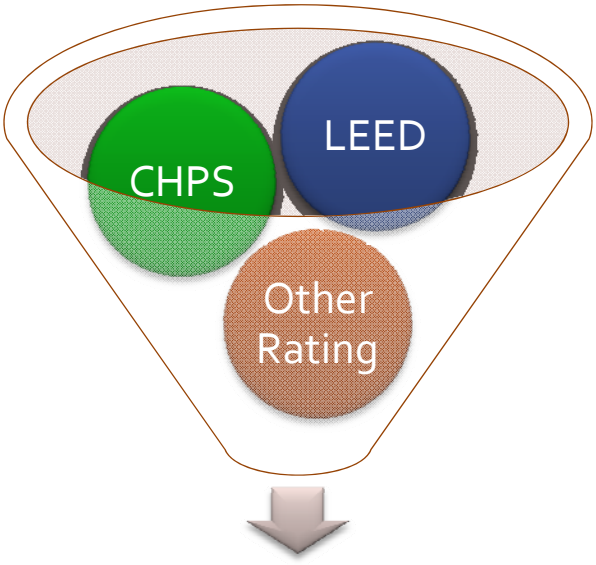
My study of the CHPS program will focus on its current state, critiquing its function and applicability. As part of this critique, I will establish a proposal of improvements to the program, after evaluating its positive and negative qualities. Additionally, I will juxtapose LEED vis à vis MA CHPS, identifying where CHPS is more rigorous and whether LEED provides more flexibility to project constraints.

It is my intent then to relate the program study back to Worcester North High School (WNHS). I will evaluate the applicability of the program and its effects on the design and construction process. Questions to develop include: What are the effects to overall project cost? Is there any value-added by creating a CHPS certified building? How has (or will) CHPS affect the project schedule? How can the CHPS program be applied in the best manner for WNHS? What are specific design/construction changes that would have added to the CHPS rating for this project?

[1] American Recovery and Reinvestment Act of 2009, Pub. L. no. 111-5, 123 Stat 115 (2009). Electronic.

The research that this requires is two-fold: first, processing/evaluating the literature and guidelines provided by the CHPS program and second, investigating the reception of the construction management industry. Input from construction managers will provide valuable information on the industry's needs, restrictions, capabilities and goals. In order to gather this input, I will conduct a series of interviews with industry professionals to glean their experiences with sustainable building rating systems. To supplement the detailed information gathered there, a survey will be developed and transmitted to a pool of willing construction professionals. A survey will provide trends in attitudes and the general reception of the industry.

The final result will be a summary of the current CHPS program, a set of suggestions to improve the feasibility of such a program, the effects of implementing CHPS certification on a design, and an opinion on the success of CHPS on the WNHS project.



Analysis Report

- Suggestions for improvement
- Role on WNHS project
- Success and pitfalls

TECHNICAL ANALYSIS 2: SOLAR PV SYSTEM DESIGN

An allowance of $250,000 was included in the original estimate for the construction of a roof-mounted solar photo-voltaic (PV) system. This system is not being actively designed or pursued, and the allowance may go unused. My proposal is to design a solar PV system for WNHS. The design must meet the $250,000 budget. Furthermore, I will conduct a constructability study on the system. Areas to discuss include the trades that would be involved (would a new subcontract be required?), effects to the current project schedule, and the consequences for implementing a PV system during this stage of construction.

A significant portion of this study will be a life cycle cost analysis on an installed PV system. There are several rebates and tax credits for PV systems, meaning that there are substantial benefits that merit its consideration. As time progresses, there are energy savings that are a direct result of the PVs. Part of the study will evaluate the payback period and maintenance costs.

First, it is necessary to research the available panel types and mounting systems, including manufacturers and specific product design types. Consulting with faculty and construction professionals is integral to this research, in order to establish a constructible, accurate solar system. Next, unit construction costs need to be figured in order to establish the projected scale of the system. It will be important to find durations for similar scale projects so that the impact on the WNHS project schedule can be determined. The system should be at a schematic design by this point. The next step will be to run an analysis on the output of the system and its effect on the electric utility demand. Finally, the system will be looked at over a 40 year life to determine the saved utility costs. Once the system is deemed appropriate, the available discounts and rebates will be compiled.

Once the system has been designed, I will discuss the features and costs with the owner/CM, an advantage to both the actual construction project and my thesis research. This will further the validity of the design as well as provide the owner/CM with a sample system that could be implemented.

The final product for this analysis will be a recommendation to the owner regarding the installation of the PV system. It will demonstrate the benefits I predict that such a system can provide, furnishing a strong base on which the owners could decide. I see this as an important analysis because it has multiple benefits, such as decreased utility costs, decreased carbon emissions, and potential increased environmental awareness for the student body.

TECHINCAL ANALYSIS 3: GREEN ROOF DESIGN

Green roofs are a common component of sustainable buildings, having numerous benefits that include diminished heat absorption and transmittance and decreased storm water runoff. With the benefits come some drawbacks: maintenance requirements, roof repair issues, impact on structural loads and the costs associated with heavier structural elements required to support the roof. It is worth the consideration though, especially if the building is attempting a sustainable certification like LEED or CHPS.

At Worcester North High School, there is sufficient horizontal roof surface that would facilitate a green roof installation. While the construction management team has successfully changed the roof material to a more eco-friendly and less heat-absorptive material, a green roof would entail structural changes, cost requirements and constructability issues. Examining the potential for a green roof means I must consider all of the impacts on the project.

I know that installing a green roof will incur costs to the owner; however I believe that the roof should be properly investigated and considered as an alternative. To meet this goal, I will start by researching the different assemblies available for green roof systems. I will consider the New England climate and available materials to narrow the choices down. Comparing cost and construction times will aid in deciding which system works best for WNHS. I will then complete a schematic design of the green roof and establish the load requirements for the structure. The next step is to evaluate and redesign the structure to support the roof. For the sake of time and scope of my thesis, I will redesign the columns for a typical bay of the school. The final product will provide a green roof design proposal with associated costs and schedule impacts. This includes the structural redesign, satisfying breadth requirements for the thesis.

It is expected that a green roof will fall out of budget capabilities for the project. I will determine the available rebates, tax credits and additions to the CHPS rating. I will also include a summary of the sociological benefits of green roofs, creating a case for their inclusion on future school projects. Also of paramount importance is the impact to the construction process that a green roof poses. This involves schedule impacts and durations, site logistics, and additional subcontracts that must be purchased. Additionally, a green roof may impact other trades and construction tasks, an influence that should be properly investigated.

TECHINCAL ANALYSIS 4: LIGHTING SCHEME RE-DESIGN

The current lighting scheme consists of fluorescent fixtures typical of schools and offices, with suspended pendant strips and parabolic troffers in the classrooms, compact fluorescent recessed fixtures in the hallways and HID hi-bay fixtures in the gymnasium. There exists a growing market for solid-state lighting, comprised of mainly light emitting diodes (LEDs) which provide "clean" light with low power consumption and high efficiency. Additionally, there are components that can be integrated into the lighting/electrical system which reduce the system's energy demands. I propose investigating the implementation of LED lighting, especially as an alternative to the CFL recessed fixtures. Also, I propose installing occupancy sensors in all spaces and daylight sensors that adjust the output of the lighting system according to available daylight. I will present two options for the electrical schedule. One will be the sole implementation of a more energy efficient system. The second will be to accelerate this portion of the schedule by 10-15%, identifying the costs incurred and the impact on related trades.

The first component of this study involves exploring alternative fixtures and electrical equipment. I will evaluate the purpose of several common fixtures on the project and replace them with LED fixtures or ones that perform at a higher efficiency. Next, I will modify the electrical system to include occupancy sensors and daylight sensors. The final step will be to aggregate costs for this system as well as modifications to the schedule. The scheduling portion will entail updating the current project schedule and establishing an accelerated schedule as noted above. This study will provide a solid case for a more efficient lighting system, with its positive and negative aspects. The scheduling allows the owner and CM to figure how this new system will impact the finish date and how an accelerated schedule can be achieved.

I expect the electrical scheme re-design to show efficiency is a viable option. While there will most likely be initial costs incurred, a life-cycle analysis will show what the payback period would be. As this building will be owned and operated continuously by the same entity, even if the payback period is 20 years, it may still be a viable option.

CONCLUSIONS

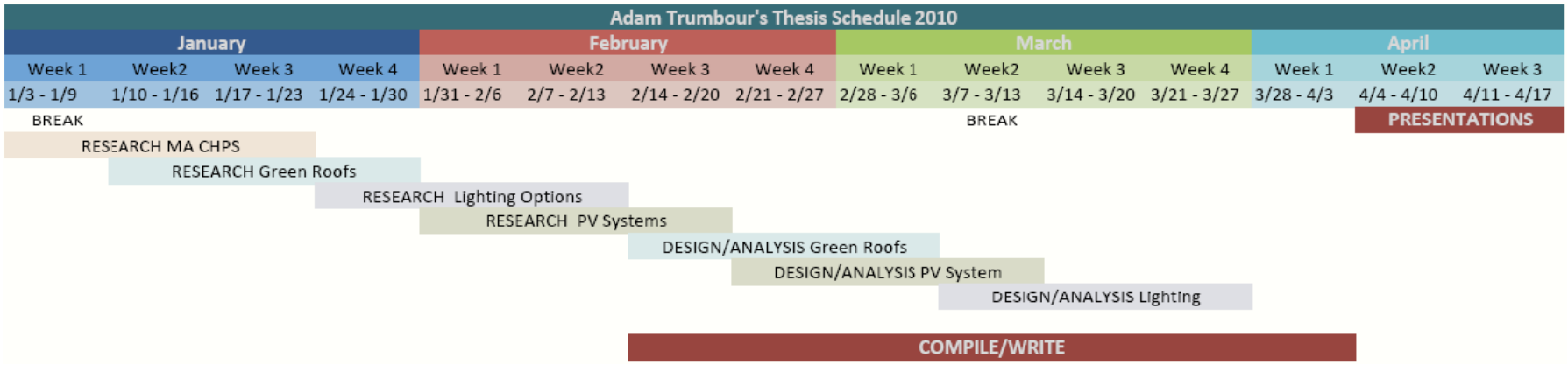
The underlying theme with my thesis is undoubtedly sustainability. This aspect of the construction industry is very important to me and I feel that the Worcester North High School project provides some areas that have possible sustainability improvements. The four analyses mentioned above aim to increase the environmental responsibility of the building, ultimately bettering the community in leading by example.

With the four topics at hand, it is evident that some research needs to be done before any analysis can take place. It will be crucial to establish a robust research portfolio on green roof technology, lighting technology, solar technology and building rating systems. I plan to approach the research as a whole, rather than accomplishing each analysis independently and successively. Learning about rating systems first, however, will help with determining what avenues to pursue in the other analysis topics I have chosen.

Hopefully, my final thesis will be a solid case for green construction. It is my goal to provide feasible alternatives that are attractive to the owner and that are backed by research.

WEIGHT MATRIX

Description	Research	Value Eng.	Const. Rev.	Sched. Red.	Total
MA CHPS	20				20
PV System	5	10			15
Green Roof	5	10	20		35
Lighting Sys.		10	10	10	30
Total	30	30	30	10	100


Adam Trumbour's Thesis Schedule 2010
January
February
March
April
Week 1
Week2
Week 3
Week 4
Week 1
Week2
Week 3
Week 4
Week 1
Week2
Week 3
Week 4
Week 1
Week2
Week 3
1/3 - 1/9
1/10 - 1/16
1/17 - 1/23
1/24 - 1/30
1/31 - 2/6
2/7 - 2/13
2/14 - 2/20
2/21 - 2/27
2/28 - 3/6
3/7 - 3/13
3/14 - 3/20
3/21 - 3/27
3/28 - 4/3
4/4 - 4/10
4/11 - 4/17
BREAK
BREAK
PRESENTATIONS
RESEARCH MA CHPS
RESEARCH Green Roofs
RESEARCH Lighting Options
RESEARCH PV Systems
DESIGN/ANALYSIS Green Roofs
DESIGN/ANALYSIS PV System
DESIGN/ANALYSIS Lighting
COMPILE/WRITE

APPENIDX 1: BREADTH STUDIES

It is an integral part of all Penn State Architectural Engineering majors is to receive an interdisciplinary education across the field of architectural design, analysis and construction. As such, the requirement exists to focus areas of thesis study which include two other breadths. I have decided to pursue structural and electrical breadths, as these are of most interest and applicability to Worcester North.

BREADTH STUDY 1: STRUCURAL

As indicated in previous sections of this report, it is my intention to research and design an appropriate green roof for the high school. Traditionally, green roofs impose substantial loads onto the structural system of the building. As WNHS is not designed to support a green roof, I will need to analyze and redesign a typical bay, specifically columns from sub-grade to the roof, as well as roof joists and girders.

The current structure is entirely structural steel, with composite decking integrating concrete cast-in-place slabs. The roof system is a PVC roof membrane over 3" insulation and gypsum roof decking, supported by W12 shapes. This assembly must be redesigned for a green roof as well.

BREADTH STUDY 2: ELECTRICAL

Attempting to render the lighting system more efficient, I will need to look intensively at the electrical system as a whole. My goal is to select different fixtures that consume less power, as well as proposing day light monitoring integration. The system as designed utilizes traditional T5 fluorescent pendant strips, T8 parabolic troffers and recessed compact fluorescents. What I intend to research is how choosing LED fixtures and integrating daylight and occupancy sensors will decrease the electrical load on the building.

Specifically, the lighting loads for the current configuration need to be determined. From there, I can compare different fixture options and their contribution to the lighting loads. Referencing solar data will aid in determining when the lights could be dimmed due to daylight. It is also necessary to determine the savings created by having occupancy sensors. Finally, combining the effects of all three of these aspects will allow me to assemble a lighting scheme that is smarter and less energy-consuming.