THE PENNSYLVANIA STATE UNIVERSITY –
DEPARTMENT OF ARCHITECTURAL ENGINEERING

AE Fifth Year Senior Thesis

Executive Summary & Breadth Studies of Thesis Proposal

Sami Boulos – Construction Management

12/18/2007

Faculty Consultant : Dr. Riley

The Carl J. & Ruth Shapiro Cardiovascular Center at the Brigham & Women's Hospital in Boston MA

Table of Contents

Executive Summary

Through the three Technical Reports, the project systems and construction methods gave way for the author to discover areas of the project that led to problems or construction issues that could potentially lead to construction issues. The following proposal is the opportunity to analyze three such problem identification areas, research the facets of each, and come up with innovative solutions that could improve the quality of the project.

Each year at the PACE (Partnership for Achieving Construction Excellence) Roundtable, students are introduced to critical construction issues in a discussion format with industry members. These critical issues can help students gain an interest and comprehension for the complexities inherent in construction practices, and also to recognize how those same issues can be applied to their own thesis projects. The issues from this year were BIM, prefabrication, and workforce relations, and the key contacts that this student could call upon are identified as well. From this, the most interesting for me was the Building Information Modeling and its growing use in the industry today.

More of a central theme, BIM will be part of the three technical analysis areas encompassing the reminder of my thesis proposal. Research into the design of the façade connections of the bridge spanning the existing hospital to the new Carl J. and Ruth Shapiro Cardiovascular Center is followed by an exploration of the acoustical complications with having a generator above the VIP patient rooms on the 10th floor of the new building, and finally finishing the analysis topics will be a critical look into the Curtain Wall system and the construction solutions for it on the project. A fourth technical analysis topic involves a second topic discussed at the PACE Roundtable, prefabrication. The finishing of the concrete floors has caused issues with the LEED-appointed adhesives used by the flooring subcontractor. So a look into using precast concrete floor slabs in the place of the cast-in-place concrete floors makes up a fourth analysis topic which may or may not be explored for the final proposal in Spring 2008. For a more in-depth description of the breadth studies in these technical analyses, refer to Appendix A.

The overall goal of this thesis proposal is to generate innovative solutions that incorporate the topics of the construction management classes (Schedule Reduction, Cost Savings, Value Engineering) with the breadth studies associated with Structural or Mechanical options in Architectural Engineering. These solutions will require research and development, as well as designing and modeling in 3-D and 4-D representations, and the weight matrix provided in the final section of the proposal indicates specific percentages of time allotted to these topics.

Critical Industry Issues

Each year, PACE, the Partnership for Achieving Construction Excellence, holds two seminars that meld industry professionals with AE faculty and students. The fall's PACE Roundtable introduces prominent industry problems or successes to the students with real-world experience interwoven via the industry members and faculty. The spring's PACE Seminar updates the students and industry members with details of the progress that industry-led actions have made to address and correct those issues discussed at the Roundtable. This year's critical industry issues discussed were Prefabrication, BIM, and workforce relations.

Prefabrication of construction materials and elements discussions commenced the PACE Roundtable this past October. Panelists discussed several sides of the issue: owner/consumer perspective, manufacturer perspective, contractor perspective and academia perspective. Some common arguments against prefab were that it leads to lesser quality products and also does not allow quick changes in design. The arguments supporting prefabrication involved the waste on site being less and that some building systems can be installed faster with prefabrication. Other discussion topics included the idea of the phrase "prefab" leading to the idea of a lower quality product, particularly in Europe where "offsite production" has been a staple in construction.

Building Information Modeling, or BIM, was the second major topic at the Roundtable, and again panelists discussed the positives and negatives of BIM. The general feeling towards BIM was that it presented a good step for the industry in clash detection and also sequencing of trades on a project. Also, there would be less waste of paper to print every RFI and also all the revised drawings, and also there would be less of a delay in schedules because the problems would be addressed at the beginning of the project before construction commences. The dissentious comments against BIM were that the software was only accessible for some trades, and that not all trades bought into the idea of BIM. This is true, but more because BIM is a relatively new advancement in the construction industry; according to the panelists, five years ago BIM did not even exist.

The final topic at the PACE Roundtable was arguably the most important and dealt with the workforce relations problems, particularly those involving illegal immigration, union relations, and also the shortage of experienced tradesmen and labor shortages. The growing trend shows that experienced tradesmen whose children join the workforce only serve temporarily as they search for "a better job". The other growing problem that decreases the workforce is the raging immigration fight. Politicians on both sides of the argument are hurting the ability for experienced tradesmen to stay in the construction industry. One statistic that really resounded was the fact that 60% of the workforce is Latino/Hispanic and that of those, one-third are illegal immigrants!

The PACE Roundtable brought up some very interesting topics to research for our thesis. The most relevant to my thesis would have to be the BIM and the prefab topics. One issue that really surprised me was to hear an owner's perspective that was against prefabrication, and also the idea of the phrase "prefabrication" being taboo in Europe. Since my project is attempting a LEED certification, I would like

to see how prefabrication of some elements of the project would have earned more points for LEED or attain some schedule savings. Also, since I am aware of a BIM effort for MEP trades on the project, I would like to see if BIM would have helped in any other segments of the project, mostly with the Bridge connecting the existing hospital to the new building. Several industry members who would be helpful to speak with are Mike Graboski and Jerry Shaheen from Gilbane, who would be able to help me with some BIM and LEED questions; Jerry is the Project Manager on the Dickinson School of Law project here at Penn State UP. Also, Jim Faust of Turner is another contact I made at the Roundtable who was very insightful to speak with about workforce relations.

Through the five years of study at Penn State, the department's curriculum has changed dramatically. However, their advancements in software and research benefit younger students, and the older members of the department suffer. 3-D and 4-D modeling practices often must be learned by the students on their own in my class, while the students just a year younger were taught those and many more of the software capabilities the AE department has in their classes. Similarly many of the trades in the construction industry are behind in the development and adoption of the new state-of-the-art computer programs that could greatly help the construction process. With more trades adopting 3-D programs and utilizing them allows more construction issues to be addressed and corrected before their construction begins, allowing more schedule savings and earlier delivery of the projects. This is the issue I would like to pursue through my research.

Problem Statement:

BIM project capabilities are readily available for all trades in the industry, but only certain trades are taking advantage of these tools. The problem is that in order for the BIM tools to reach their full potential and to increase quality of projects, all trades need to adopt these tools and work together.

Goal of the research:

The goal of my research is to find out the deterrents of trades in the industry from adopting BIM tools, and to hopefully find solutions to their opposition and to present them at the PACE Seminar in Spring 2008. The audience of my research is the construction industry as a whole, but I would like to get a representative group of trades who use BIM and some of those who oppose it. The benefits of my research will be felt by all trades in the construction industry because as stated above, BIM will reach an optimal efficiency when all entities involved in constructing a building (all trades, contractors, and owner) work together.

Steps:

The research will begin with a literature review of articles in periodicals and other published works pertaining to BIM. Also, a survey of industry professionals that will give an objective analysis of BIM usage, knowledge of BIM, and the perspective of BIM in the industry, will demonstrate certain areas of further research and potential solutions to help re-introduce BIM to the industry.

Below is a draft of some of the questions that will be used to determine the knowledge of BIM and its processes in the industry.

Question 1: Have you ever heard of BIM or Building Information Modeling? If yes, can you describe it?

Question 2: Do you have any previous experience using BIM, or have you worked on a previous project that utilized BIM?

Question 3: How many trades are you aware of that use BIM?

Question 4: Do you think BIM is a good tool that should be used more frequently or is not a good tool to have in the construction industry? Please justify your answer with sentence or two of support or testimonial.

A survey of 15-20 questions will be generated and sent to members of the construction industry who would be willing to help me in this research gathering task.

Technical Analysis Descriptions

The Carl J. & Ruth Shapiro Cardiovascular Center is going to be the premier healthcare facility in Boston, with state-of-the-art Operating Rooms, Imaging systems, and the ability to address a multitude of patients while still being a central research campus for medical students in Boston. The level of quality and accuracy in project task completion is critical to the hospital, but the project was not without problems. Apart from trying to implement further Building Information Modeling into the project tasks, the following are the Analysis topics to be researched and presented in April of 2008.

Analysis 1: One major component of the new Carl J. & Ruth Shapiro Cardiovascular Center at Brigham & Women's Hospital that required a large coordination effort was the bridge connector between the 2 buildings. In order to incorporate the breadth within the analysis, I have chosen this segment of the project to redesign. Problem Statement: **From the problem identification segment of Technical Report #3, a component of the bridge connection deserves some analysis and potential re-design: the bridge connections to the existing hospital's façade.**

The research and development encompassed in this analysis topic will help the project in several ways. The realistic goal is to find a better quality connection for the bridge to the existing hospital, and the research goal is to examine if incorporating BIM into this phase of construction was possible and logical. Would BIM have been able to detect this issue before construction began? If so, how much savings on the schedule and money would BIM have provided the project and the owner? I will need to research various types of bridge connections to buildings and also if BIM would have been possible for this project.

For this analysis, several research steps will be taken

1. A conversation with the project manager and project team members in order to better understand the construction issues involved with this project phase. Drawing details, any as-built drawings of the existing hospital, any other architectural design details, could all be recovered and researched.
2. Discuss with the subcontractor responsible for the bridge connections about the work and ask their opinions about the project; what issues they saw were necessary to cover that may or may not have been addressed. Also, discuss with them Building Information Modeling and ask about their previous experiences (if any) with that tool and how it could have benefitted the project.
3. Research online documents and any other texts or literature regarding the structural elements of bridge connections and attaching to building façades. This is to be done in order to gain knowledge for a potential re-design of the connections and alternative solutions to the design.
4. Come up with a solution to the bridge connection design by asking a series of questions in the form of a phone interview with the subcontractor, with the permission of the owner and the Construction Manager.
5. Find other projects that have had similar problems with bridge connections and gather information about their solutions. Are there any patterns in the solutions?

6. Present your solution to the Project manager of the Carl J. and Ruth Shapiro project and ask for his advice. Is it a worthy solution? Could it be helpful to pass it along to the structural engineer for analysis?
7. Summarize the results of your analysis and solution and show a comparison and contrast against the actual solution. Focus on the value added/ taken away from the project, i.e. any cost savings/ losses, time saved/ lost on the schedule, acceleration of the schedule, and also if the owner would accept or reject the solution.

With this analysis, the knowledge gained by conducting interviews with members of the project team, subcontractors, and also the owner will help for future problem resolution. It will show just how much energy is needed to adopt BIM for projects and show the general opinion of BIM from subcontractor and owner perspectives, not just from the CM standpoint. The solution may not be better for the project and may actually lose more time and money than it would save, but it could show that creative thinking on another project might be beneficial, and the positives through BIM might also be established as possible standard practices for future projects.

Analysis 2: The second problem area that interested me enough for further analysis was the acoustical vibrations on the VIP 10th floor. These rooms service the patients of higher social status, and are located beneath large generators. Considerable money and labor has been spent on sound and vibrations dampening in order to provide and maintain the luxurious atmosphere in those spaces. **Problem Statement: The vibrations and sound coming from the generator located above the VIP rooms on the 10th level required a large amount of dampening in the design of those spaces.**

As an acoustical breadth, I would like to analyze those vibrations and sound issues and perhaps find an alternative solution that still meets the high vibration and sound transmission control, but for a cheaper price and less labor. In order to accomplish this task, in-depth research and the following steps must be taken:

1. Begin by gathering information about the present solution and research those products, including their acoustical properties and cost. This can be done by accessing the submittal information from the Construction Manager and then researching these materials via Internet sources, periodicals, and manufacturer's guides.
2. Once the research has been done, examining the data on the generator and its vibration and sound properties, i.e. how much sound in decibels is transmitted or how much of a vibration is caused when the power level of the generator is at a certain level?
3. Next, a logical survey will be generated for the project manager and several industry professionals specializing in mechanical equipment and acoustical analysis. This survey will ask these individuals to comment on certain products used to dampen sound and vibration commonly used in hospitals and/or "green" building projects.

4. The survey will be sent out to some industry professionals and their responses will be analyzed to find a specific pattern in their answers, such as specific products being used by the majority of the industry. This survey will also inquire as to their familiarity with BIM and if it could be employed to discover acoustical solutions.
5. From these inquiries, a proper solution will be made, comparing it against the project solution. They will be weighed with cost savings, time saving, and other considerations as well. The report will be presented to a proper authority on the subject and then the results will be summarized for presentation in April to the AE Jury.

Since Acoustics has been a strong consideration for this project, as well as the idea of a VIP hospital room has been intriguing for me, this analysis helps to strengthen my acoustical appreciation on construction projects and better understand the necessity for acoustical analysis. Another strong aid from this segment is the ability to apply creative thinking and solution design into other facets of a construction project. The ability to think of these critical construction issues will allow me to manage a project more smoothly, with knowledge of potential labor considerations necessary to allow the project to succeed. Lastly it will reinforce my desire to consider the client's needs at all times on a project and help find the best solution to fit his or her requirements.

Analysis 3: The curtain wall system for the building actually consists of 3 different methods of construction adopted for different heights of the building, i.e. the fourth floor is entirely louvers in order to achieve the outdoor air intake for the building, and the curtain wall on the lower 3 levels implements a different system than those floors above level 4. **Problem Statement: The various curtain wall systems require more coordination and construction issues, i.e. different connections to the steel frame.**

The curtain wall is a major component to the building envelope, and it extremely important to construct accurately. I have several goals in mind to accomplish in this analysis. The first is to gain a better understanding and more knowledge about the various systems used for curtain wall construction. Second, I hope to establish a more uniform type of curtain wall system in order to save both time and money on the project. Lastly, in continuing the theme of BIM, I would like to see if the tools of Building Information Modeling would have been a help in seeing connection issues and other curtain wall issues beforehand on the project. Listed below are some steps necessary to accomplish this:

1. Begin by gathering information about the present solution and research those curtain wall systems, including the R-values and other thermal properties and the costs associated with each. This can be done by accessing the submittal information from the Construction Manager and then researching these materials via Internet sources, periodicals, speaking with the contractor (with permission of course) and manufacturer's guides.
2. Next, a logical survey will be generated for the project manager and several industry professionals specializing in curtain wall systems. Questions will be in regards to products, materials used in construction, and issues that must be considered when designing a curtain wall system. Lastly, some opinion questions in regards to BIM and their experience will be given

in the hopes of discovering clues to help adopt better implementation of BIM into the other facets of construction other than MEP trades.

3. The survey will be sent out to some industry professionals and their responses will be analyzed to find a specific pattern in their answers, such as specific products being used by the majority of the industry. This survey will also inquire as to their familiarity with BIM and if it could be employed to discover acoustical solutions.
4. From these inquiries, a proper solution will be made, comparing it against the project solution. They will be weighed with cost savings, time saving, and other considerations as well. The report will be presented to a proper authority on the subject and then the results will be summarized for presentation in April to the AE Jury.

The expected outcome of this survey and the research will be a comparison of the curtain wall systems used on the Carl J. and Ruth Shapiro project, and a potential uniform curtain wall solution. Also, there is a hope for sound recommendations with regards to BIM implementation into the curtain wall phase of construction projects. Also, an outcome of this analysis will benefit me when discussing curtain wall systems in the future while in the industry. Since it has never been a strong concentration for me before, I hope to gain invaluable knowledge of the concepts, the materials involved in the design and construction of curtain walls, and their applications to buildings.

(Potential) Analysis 4: If there is enough time to do this research, I would like to research the possibility of changing the flooring systems in the patient levels of the building from a Cast-In-Place concrete floor system to a Pre-cast concrete floor system. **Problem Statement: Floor moisture due to the finishing of the floor decking is causing problems with the adhesives being used to install the floor finishes and is also related to the LEED Certification process and the VOC violations of certain adhesives.**

When a building is striving for LEED Certification, one factor for gaining LEED points is the amount of VOC (Volatile Organic Compounds) released into the air by construction materials. Certain glues used for the flooring are restricted for LEED projects, so the flooring contractor needed to use a non-solvent based adhesives for the floors. Because of the finishing on the floors causing too much moisture, these LEED-approved adhesives perform poorly and force more labor and money into finishing the floors again. This oversight was not planned and may not have been prevented by any form of BIM, but Prefabrication was discussed at the PACE Roundtable, and a switch to a Pre-cast concrete flooring system would prevent this issue from happening. The steps in researching this topic:

1. Discuss with the project manager if the idea of precast flooring was ever considered. Do some research about precast flooring and its application history to healthcare projects? Search through periodicals and other literature.
2. Research the location of precast concrete manufactures within the distance between the site and the allotted distance of LEED restrictions. Contact them and ask questions about precast flooring and gather information about the process.
3. Once all information is gathered, come up with a potential solution for replacing the cast-in-place concrete floors on the project with the precast flooring. Present this idea to a structural

faculty member or possibly some PACE industry members with whom spoken to at the Roundtable. Take their comments and revise the solution.

4. Summarize your results and compare the two floor systems to one another. Note all cost and schedule implications and logically illustrate them in your presentation in April 2008.

With the research done into the prefabrication of flooring for the hospital, this analysis will solve issues of the moisture and non-solvent-based adhesives used for LEED projects. Also it will introduce the concepts of prefabrication to the project which may save time and money. However, some snags will be the time the crane is onsite, will the crane have the reach and capacity to hoist the precast slabs into place, and also if the construction team has experience with precast floor slabs?

Weight Matrix

Description	Research	Value Engineering	Constructability Review	Schedule Reduction	Total
Analysis 1 – Bridge Connection	5%	5%	10%	5%	25%
Analysis 2 – VIP Acoustics	5%	5%	0%	5%	15%
Analysis 3 – Curtain Wall	5%	10%	5%	5%	25%
Analysis 4 (opt.) – Precast Floor System	5%	10%	10%	10%	35%
Total	20%	30%	20%	25%	100%

Throughout the Spring 2008 semester, this is the amount of work I endeavor to expend on these topic areas for my final Thesis Presentation in April. A strict adherence to the weight matrix above will allow me to develop a simple Building Information Model that could help in my technical analyses. The model will serve as a tool to help my comparison of the project solutions and my solutions.

Appendix A – Breadth Studies Summary

Through the course of researching each technical analysis topic, each incorporates components of other disciplines of Architectural Engineering. These breadth studies are taken from Structural, Mechanical, or Lighting/Electrical options studies, and are interwoven into the analysis subjects listed in this proposal. This section was specially prepared to better explain the breadth study component for the analyses, and also to prepare the breadth studies segments of the Executive Summary and also for the CPEP website component.

Analysis 1 Breadth: Since this analysis revolves around bridge design, considerable attention will be spent on the structural impact of changing the bridge connections to the façades. The structural analysis of the bridge with dead and live loads will be needed for both the existing design and any changed designs in order to choose the best application of connections to the existing hospital. This may involve also wind lateral loading conditions, snow loads, and any other structural components that may compromise the bridge connections.

Analysis 2 Breadth: This analysis focuses on mechanical systems and acoustics as breadth topics. For the mechanical side of the breadth analysis, the HVAC systems and generators put out so much vibration and sound, and this will be analyzed. Acoustically, the vibrations and sound dampening must be determined and analyzed to find the appropriate materials to meet the requirements. These will then be used to compare with the design choices made for the project.

Analysis 3 and 4 Breadths: Both of these analyses involve a great amount of structural breadth opportunities. The curtain wall system must repel certain wind loads, has some load attributed to it, and both of these are considered when structural design occurs. Thus any change to the design of the curtain wall system dramatically impacts the structure. In the floor system analysis, the cast-in-place concrete must meet certain engineered strength requirements, and a precast floor system designed to replace the cast-in-place floor system must meet the same requirements. Also, the precast system might have other strength issues that must be addressed, i.e. the connection between floor slabs, if not properly grouted, could compromise the structure.