

THE PENNSYLVANIA STATE UNIVERSITY –  
DEPARTMENT OF ARCHITECTURAL ENGINEERING

# AE Fifth Year Senior Thesis

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## Technical Report #3: Alternative Methods and Research

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## Executive Summary

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The third technical report begins to identify project areas that interest the student and can be explored in great detail as part of their proposal for thesis. Critical construction issues coupled with project specific problem identification give students an idea for what topics would be good to apply analysis to in their thesis research. Breadth studies in areas not related to construction management can be incorporated in these analysis areas.

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 follows one particular research topic with a problem statement and resolution ideas and information sources necessary to arrive at a solution or conclusion.

Going from a broad industry spectrum to the thesis project itself, the identification of problem areas in this building comes before the technical analysis, where a few themes intertwine breadth of study and other construction issues and focus around a central area of the project. Next the weight matrix segment illustrates the distribution of efforts on each analysis topic.



## Critical Industry Issues

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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.



## Critical Issues Research Method

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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.



## Problem Identification

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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. One major area of issue was the bridge spanning Francis Street and connecting the existing Brigham & Women’s Hospital with the new building. Steel connections were an area of concern, as well as tying into the existing structures exterior façade. Below is a list of project-related problems and potential issues of construction that can be addressed in my thesis research:

1. As stated above, the bridge connection between buildings. Connections on the existing façade to the bridge were problematic.
2. The aesthetic design of the bridge was a matter of dispute as well; the steel members are exposed with an all glass curtain wall.
3. The lobby on the east end of the new building is 3 stories in height and is very open. I would like to research the acoustical issues in that area and the methods of sound dampening utilized to see if there was a more economical or more “green” method that could have been used. Also, I would like to see if the methods employed are successful or not.
4. The curtain wall system for the building actually consists of 3 different methods that were unique for different heights of the building, i.e. the fourth floor is entirely louvers in order to achieve the outdoor air for the building, and the curtain wall on the lower 3 levels have a different curtain wall system than the floors above level 4. I would like to research the curtain wall systems used and see if a more typical system could be used on all floors except the fourth floor.
5. In the existing lobby area of the Brigham & Women’s hospital, there are large staircases that ascend to the office levels, but in the new building, there are three sets of escalators that lead to the upper administrative levels of the hospital. A portion of the southeast wall of the building was left open in order to install these escalators, which came fully assembled to site. I would like to research this in further detail, and to see if any other alternatives existed.
6. Site congestion is an extreme problem on this project. Apart from the extremely small amount of space on site for equipment and trailers, there are no lay down areas for steel or other materials and no loading dock for the project. Therefore, there was considerable effort spent in coordinating material deliveries to site.





7. Another area of acoustical significance is the level 10 VIP rooms that sit just beneath the Rooftop Air Handling Units. Considerable time and effort was taken to ensure that the vibration from those units was quelled in order to maintain a pleasant living condition for those VIP rooms.
8. Floor moisture due to the finishing of the floor decking is causing problems with the adhesives being used to install the floor finishes. When a building is striving for LEED Certification, one component is the amount of VOC released into the air by the construction materials. Certain glues used for the flooring are not permitted for LEED projects, so the flooring contractor needed to use a non-solvent based adhesives for the floors, but it is causing too much moisture on the floor decks.
9. The foundation walls gained several redundant waterproofing systems due to a problem coordinating the sequence with multiple trades and a lack of understanding by all parties involved. Issues with the drawings, coordination, and not having everyone on the same page caused delays in the tasks being done and cost more in redundant waterproofing.



## Technical Analysis Methods

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Listed in the previous section are some problems that could occur on this project. From these, some areas of analysis are represented below. Along with the problem is a description of the steps needed to complete the analysis, the tools and research involved, and the building systems involved.

**Analysis 1:** The major problem area on the project was the bridge connector between the 2 buildings, so this will be one analysis topic. In order to incorporate the breadth within the analysis, I have chosen this segment of the project to redesign. I will need to research steel connections for the bridge, as well as curtain wall systems that would be appropriate for it. With this research, 2 new ideas will be proposed that will maintain a similar style while improving the steel connection process and some of the aesthetic discomforts with the bridge. Not only will the owner's design criteria be researched, but also the method of constructing the re-design; the new design will try to incorporate some solar or "green" construction elements as well. Finally, a look into the cost of the re-design will be explored from a value engineering aspect in order to show that if in fact the re-design takes more time and more money, the owner will be more satisfied and this new design will provide more quality to the project.

**Analysis 2:** The second problem area that interested me enough for further analysis was the acoustical vibrations in the lobby area and their resolutions. This is a large open space that will accommodate many visitors to the hospital and also the families of patients and medical students alike. I would like to see if the current solution to dampen the sounds and vibrations is adequate but also to see if there are any "green" products that could be used instead. The research involved will require a complete acoustical analysis as well as submittals of the current acoustical system. Also, a sufficient research into "green" acoustical solutions will be required.

**Analysis 3:**



## Weight Matrix

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Description	Research	Value Eng.	Const. Rev.	Sched. Red.	Total
Analysis 1 – Bridge	25%	15%	15%	15%	55%
Analysis 2 – Lobby	20%	15%	10%	10%	40%
Analysis 3 – Site Congestion	20%	10%	5%	15%	50%
<b>Analysis 4 (optional)</b>					
Total	65%	40%	30%	40%	