Technical Report 3

State College, PA

320 W. Beaver Ave.

Student Apartments

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Executive Summary

320 W. Beaver Avenue is a multi-use building created on the edge of the downtown area in State College, Pennsylvania. The building will be used for commercial and residential purposes, two blocks away from the Pennsylvania State University. This is a prime location for this type of building, meaning there will be no trouble renting all of the apartments when the building opens. This area is also a good location for the commercial side of the building, due to the amount of stores in the area and will hopefully bring in an ample amount of revenue.

320 W. Beaver Ave. is a $15,000,000.00, 7 story building containing: 3 levels of parking (2 of which are below grade), a small commercial space for rent that can accommodate 2-3 small stores, and the rest of the building, floors 2-7, are student apartments, 10 one bedroom and 55 two bedroom apartments. The project is constructed with cast in place concrete for the parking garage and the first floor, and then switches to CMU walls. All the floors are constructed of pre-manufactured planks, which allows for a shorter construction process. This is a very simple building except for the excavation process due to a certain issues, which are discussed in the local conditions and the building systems sections.

Included in Technical Report #3 is a reflection of the P.A.C.E. Roundtable Discussion, which is an event that involves Construction Management students as well as Construction Industry members. During this event current issues are discussed and analyzed. The three topics from this year's discussion were as follows: Prefabrication, Building Information Modeling, and Workforce Development. The rest of this repot consists of what research and redesign will be looked into for 320 W. Beaver Ave. First, is the start of what research is to come involving the cost of sustainable design or lack thereof for that matter, followed by a description of what sustainable improvements could be made on 320 W. Beaver Ave. Next is a description of the two analyses' that will be conducted, which includes implementing a green roof and a radiant floor system. Technical Report #3 is finalized with Table 1: Weight Matrix, which shows how efforts will be allocated with the research conducted.

Critical Industry Issues

Penn State hosted the 16th Annual Partnership for Achieving Construction Excellence (PACE) roundtable event on October 23rd and 24th, 2007. This event is an opportunity for students and corporations to interact and discuss current industry issues, as well as the future within construction management. During this year's meeting there were three particular issues discussed, the first was Prefabrication, the second Building Information Modeling (BIM), and the third Workforce Development. Each discussion contained four panel members consisting of an owner, a designer, a builder, and an academic, allowing for different perspectives on the given topic.

Prefabrication

Prefabrication, when referring to construction, is the idea of having components of the building pre-built in a factory or another location and then transported to the construction site to be assembled together. There are many different types of prefabrication, which primarily depend on the size of the sections. This is generally decided on by what the actual sections are, for instance if the sections are wings of a building it is done differently then sections of ductwork, based on sheer size. The amount of connections in a particular section, along with the amount of connections between the sections will play a major role in whether or not prefabrication would make sense for the project.

There are many advantages to prefabrication. Prefabrication can significantly decrease the construction time on site by allowing much of the work to be done somewhere else onsite or even offsite. This construction method allocates parts of a building to be put together in fewer pieces, more like LEGO®'s then from scratch. If prefabricated, especially in a factory setting, the pieces could be mass-produced to a point, meaning that all the tools, materials, and people are readily available, which allows for a more efficient process and could potentially reduce construction time and waste. Waste has a greater potential for being diminished by a construction worker who does not have to relocate all their tools, materials, and scrap. Therefore, the worker could have a dedicated workspace to create the prefabricated sections of the building. Having this type of environment could also produce a better quality product, due to more consistency. This established atmosphere could lead to a safer construction process as well, allowing more work to be completed outside of the job site yielding less congestion on site. For newer applications, such as solar panels being applied to the façade of the building, unions have difficulty deciding on which trade should get the work. Sometimes multiple trades have to work together and oversee each other just to make sure that their part is done correctly and that they get paid, which can be very costly. However, prefabrication can settle this dispute an easier fashion. The panels could be assembled off site without union involvement, shipped to the site, and just put into place.

There are also some disadvantages to consider when looking into prefabrication. Depending on what type, size, and weight of the sections that are being prefabricated, these sections can become very difficult to transport. If the parts are coming from far away distances and are much larger units now that they are assembled, it is probable that costs would increase and in reference to sustainability, there would be a dramatic increase in fuel emissions. These variables can arise into a similar problem when installing the sections. Another key issue with prefabrication is the difficulty in changing the design once you have sent out the drawings. This ties a designer into a plan, at an earlier state in the process due to lead-times for a particular module, which cannot be changed without a likely jump in actual costs. Prefabrication requires the sections to be assembled before construction starts so that they are ready when needed, otherwise the construction schedule would not be shortened. Also everyone within the project needs to be on the same page, which can be quite difficult, especially with larger complex projects.

Building Information Modeling (BIM)

BIM tends to be a term thrown around with multiple meanings, which was the first thing addressed at the roundtable about this topic. Each panel member defined it in their own words and came to the conclusion that it is an informative computer model that is used to coordinate different aspects of the building in virtual space rather than out in the field during construction. BIM could be used to coordinate a construction schedule, different elements of the building, energy analyses, et cetera, through a computer model. It can simply be used in a meeting as a visual aid or even cut down on waste by using computers and less paper. Most of the discussion was geared toward the disadvantages of BIM and problems that need to be faced to allow it to grow and become mainstream. Two main issues conversed about were the standardization of the software and properly communicating the advantages to a buildings' owner.

At the current state in industry, there is still trouble working with different software, most of which even now has a way to go until it can be utilized to its fullest potential, at which it could become a standard in design and construction. Some difficulties with software working between one another is that it leaves one with an uncompleted package. To get the complete package, multiple models using different software need to be constructed to analyze the building to its fullest extent. Imagine, if only one model would need to be constructed and that same model could be used to develop construction documents, energy analyses, procurement quantities and lists, coordination between trades, visual aids, et cetera, one might not even need a paper set of drawings, they could be emailed to a palm pilot and be used as 3D drawings

on site. The possibilities of BIM are endless and in reality, could significantly alter the way that our construction industry works, regarding drawings and coordination.

Communicating the benefits of BIM to the owner is the other major problem. It can be challenging to interest an owner in an investment where there is an additional upfront cost and a great deal of time spent. The truth is BIM can avoid costly problems in the field, it has been said that avoiding one costly problem can offset the cost of implementing BIM into the project. Owners want to reduce the initial cost as much as possible and typically prefer the building completed as soon and as cheap, as feasibly viable. Throughout the events discussion it seemed as if no one answer was reached and no easy way to convince an owner that BIM was worth the investment without the fact clearly laid out in front of them. However, with some owners, personnel can advocate BIM and even have information and data to back it up, which is not widely available in today's industry. Yet, it may mean nothing because change is too difficult for some owners to grasp. As an industry, we just need to keep educating and proving that it is worth the investment, while developing more solid data.

Workforce Development

The amount and quality of labor has been at a lower standard then before in the Washington D.C. area. Dr. Riley laid out a couple statistics, the first was that there is a decrease of 30% in the amount of new labor; the second was that there is a 10% increase in the number of workers retiring. These reasons are why it is important to bring new workers into the industry. There were several ideas on how to do this throughout the discussion. Some thought that education of construction should start earlier into childhood to peak more interests sooner. Many felt that there should be more television shows similar to 'Bob the Builder' and this curiosity would get more people to join the workforce, as well as begin to teach children about construction. Keeping laborers was another problem addressed with some possible solutions. The most significant change of these resolutions for the general contractor was to offer a raise, as well as better or additional benefits. Smaller alternatives mentioned that could be done to help are ideas like free parking or gifts, such as food. On top of this would be to talk to the workers about their long-term goals and future within the company.

Many of the workers in Washington D.C. today are minorities. There is the potential possibility of some of them being illegal. How many no one can be sure, but this is a problem that could have an adverse affect on all workers, production, and liability. This leads us into another predominate difficulty within workforce development, the language barrier. A great deal of the workforce cannot speak English and many more only speak a little, which can be a very difficult thing to manage. The idea of language courses for managers was brought up. However, this solution was tried in the past and was constantly overlooked when budget and

scheduling became more important. Due to this problem, bilingual characteristics are sought after from potential employees.

Application to 320 W. Beaver

Prefabrication is used for the floor structure of the building as well as the exterior finish of EIFS. Due to the fact that the crane is already in place, prefabrication in other parts of the building could be used. A great deal of the cast in place concrete and the CMU walls could easily be prefabricated. Currently, one lane of Beaver Ave., the street at the front of the building, needs to be shut down for shipments of the floor planks. For walls to be prefabricated there would further traffic problems and there is not enough space to store the multiple wall sections. If it were not for these disadvantages, prefabrication could be a perfect fit for 320 W. Beaver Ave.

The implementation of BIM into 320 W. Beaver Ave. could be useful, although it may not be worth the investment due to the project's simplicity. Depending on how many coordination problems are left in the project, which is probably not enough to consider BIM even with all the other benefits of the project.

Critical Issues Research Method

Problem Statement

Green buildings, what are green buildings? Is green just a rating system for publicity reasons? Many know about sustainability and green buildings more through LEED then the actual concepts behind it. Also many people think that 'being green' is too expensive, which I heard numerous times at the carrier fair from Construction Managers and General Contractors. This is one of the biggest misconceptions made about sustainability, especially by many owners, designers, and builders. Even though many think these negative thoughts, they are starting to design and build based of the LEED system saying that it is 'in style', that it is 'big' right now, or that an owner requested it. They are missing the point and fail to realize that a change is starting for a reason. Sustainability actually makes sense economically and needs to happen to help combat Global Warming, along with the destruction of planet earth by the human race. Whether or not Global Warming is truly that severe, green buildings are attempting to fight 1/3 of the U.S. energy problems, by making buildings more self-sustaining and occupants healthier and happier. That should be reason enough to implement sustainability into everything we do, especially in today's world.

Goal

320 W. Beaver Ave. has not had much thought about being a green building or becoming LEED certified, which is what I would like to change. Therefore my research will look into ways to make 320 W. Beaver Ave. more energy independent, by implementing more efficient and environmentally friendly solutions that will save money in the long-term. My research will look at finding ways to make this building stand out through sustainability thus giving this building a positive image, hopefully making 320 W Beaver Ave. a more desirable building to live in and the potential to increase monthly rates. Maybe, even with the possibility of being successful enough to have a waiting list to get into the building.

In depth research needs to be performed on projects that have successfully designed and built green buildings at minor additional cost, as well as buildings that have short payback periods. My research will look particularly at design decisions that influenced the performance and cost in an effective way for the project. For example, maybe the mechanical room location changed to provide simple shorter runs decreasing the cost of piping and labor, making it easier to build. Creative solutions tend to be the answer to the challenges of implementing a sustainable mentality toward a building as well as life itself, however how often are the solutions in fact the simple one?

Research Steps

- Interview designs, owners, and contractors about the success of green projects.
- Examine case studies of sustainable buildings and how they succeeded.
- Develop a spreadsheet of sustainable ideas, how efficient they are, and how much money they save in terms of payback.
- Develop a spreadsheet of what systems and parts of building impact others and the amount they cost as well as the amount of energy they use.
- Present the spreadsheets with industry members and professors and acquire feedback.
- Make any necessary changes and record all steps.

Problem Identification

There are many areas of 320 W. Beaver Ave. that have the potential of being more environmental friendly as well as more efficient and implementing cost effective alternatives. Problem identification will look at different areas that could be improved upon in a sustainable way.

The Roof

Above the commercial space is a large standard flat roof with some HVAC equipment on it. Potentially an eye sore, to both the buildings in close proximity that would look down onto it and the students in the above apartments, could be avoided. Therefore, this is an area that could possibly be a defining characteristic of making the building green. An improvement to the commercial roof space may not have an impact on the schedule because it can be worked on while other work is being done on the apartments. However it will have an impact on cost, but on the upside it would increase the worth of the building and potentially the worth of each apartment space especially on that side of the building. It could also be turned into a usable space for the apartment owners, which might increase the number of prospective renters.

Mechanical Consolidation

At the moment the mechanical system is split into many different pieces throughout the building. The commercial spaces each will have their own heating and cooling upon tenant fit out. Each apartment has its own heat pump for heating and cooling; additionally each bathroom has an additional electric wall heater. The corridors will also have their own cooling and heating system and the same is true within the parking garage. Cost could be reduced if some of these systems were combined; this would allow for one larger piece of equipment rather than many smaller pieces units. This could also decrease the time of installation as long as the distribution does not have many further challenges due to the consolidation.

Mechanical Efficiency

The systems currently in place are not as energy conservative and environmentally sensitive as feasibly possible. There are two combustion water heaters in the basement with one large tank for the domestic hot water and the corridor's heating systems is gas fired. For each apartment, the system does not include any type of energy recovery. If these systems could be combined it would make energy recovery more attainable, as well as make the building healthier by allowing the system to bring in more fresh air without as much energy loss.

Materials

There are many opportunities in making the materials in 320 W. Beaver Ave. more environmentally conscious. With the large amount of concrete used in this project, there is a significant amount of CO_2 emitted into the atmosphere during the production of the cement along with the curing process of concrete. Substituting fly ash for much of the cement would be extremely beneficial to the project and the environment. Fly ash is less expensive then cement and in many cases stronger, it also gets rid of a byproduct of coal burning. This could be done in every concrete section of this building, but on some sections, collaboration with the floor plank manufacturer and the CMU manufacturer will be necessary. There are many other materials that can be looked at or not looked at for that matter. The floors could be left as concrete if finished correctly, which could give a nice modern look to the building on the inside. This would eliminate the need for carpet as well Vinyl Composition Tile (VCT) and the installation of both, the cost and labor involved with those materials could go into a nice finish for the concrete which could increase the worth of each apartment as well.

Excavation

The excavation was the most problematic part of the construction project. The most trouble arose due to the amount of rock in the soil, which required drilling and blasting. These methods can become dreadfully expensive and has the possibility of being avoided if the parking garage was above ground. This might have saved a great deal of money; however it would have impacted many aspects of the project, such as the aesthetics, the commercial space, the height of the building, and the location of the apartments. This would require a complete redesign when time is already an issue, as well as possibly hinder the building.

Technical Analysis Method

These are areas of 320 W. Beaver Ave. that can be improved through sustainability and cost.

Green Roof

As stated in the Roof section of Problem Identification, the roof has the potential to be so much more then it is. This can be seen to the right in Figure 1: 320 W Beaver Ave. If the commercial space's roof were changed to a green roof that is accessible by the people that live there, this could be a great study space for students as well as a nice place to hang out. There are several issues when formulating this change, to have the green roof make a statement for the building, it would have to be plainly visible from the street. One-way to accomplish this would be to let the roof to be an intensive green roof, such as a garden. The railing system will be important, they are expensive and it should allow one to see that there is something interesting on the roof and would make them wonder about what it is like. The other issue is the mechanical equipment located on the roof would need to be sectioned off or more desirably, moved. There are also apartments that have windows that look directly out to the roof. This would invade someone's privacy, so planting would be used to shield people from looking into the 2nd floor apartments. One more issue, the building needs a little redesign in order to allow for access to the roof. Breath 1, will be looking at the redesign of the building and the roof itself from an Architectural perspective. The last issue, Breath 2, analyzing the structure below to make sure that it can hold the new green roof. If not a redesign of the structure that carries the loads down through the parking garage will be needed.

Figure 1: 320 W Beaver Ave

Radiant Floor System

If the carpet and VCT were removed exposing a concrete floor a nice addition would be to implement a hydronic radiant floor system. This could be used to heat the entire building and can be controlled just as well as the different systems if done correctly. This would allow for consolidation of the heating systems and allow for a potential downsizing of the heat pumps for each apartment. Even though it provides a more efficient system, it might possibly be more expensive. I will analyze these costs and see how long it would take for the system to pay for itself. These adjustments will most likely have an impact on the schedule. The radiant floor would need to be installed before the topping slab is poured adding an extra week to the schedule, thus adding one more step in the construction from floor to floor.

Weight Matrix

The table below, Table 1: Weight Matrix, demonstrates how my time and effort will be dispersed throughout the next semester.

Table 1: Weight Matrix

Description	Research	Value Engineering	Construction Review	Schedule Reduction	Total
Cost of Sustainability	25%	----	----	----	25%
Green Roof	----	25%	5%	5%	35%
Radiant Floor Heating	5%	20%	10%	5%	40%
Total	30%	45%	15%	10%	100%