Community Healthcare

Mid-Atlantic

PROPOSAL

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PERKINS + WILL

DPR CONSTRUCTION

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Table of contents

Executive Summary

Community Healthcare is a medical office facility under construction in the Mid-Atlantic region. The design intent is to create a three story healthcare project to extend the network of care to the local community. The goal is to create a space where the specialists come to the patients and not the other way around. The primary tenant of this facility has a long standing history of providing exceptional healthcare to this community and has teamed up with Frauenshuh HealthCare Real Estate Solutions, one of the leading developers of medical office and ambulatory care facilities, to create this building.

The flat site in this suburban neighborhood drew attention from other corporations interested in developing the site as well. Fortunately, the primary tenant of this facility was warmly welcomed by the community and is expected to complete construction in January 2016, just 15 months after the issuance of the notice to proceed.

Frauenshuh brought Perkins +Will on as the architect of record and DPR Construction as the construction manager. This project was split into the core and shell (C&S) as one GMP package and the tenant interiors (TI) as another, of which both have the same project partners. While Frauenshuh holds both the C&S and TI contracts through their LLC, Frauenshuh is most interested in the C&S and the primary tenant in the TI. This medical office building is set to open in the spring of 2016.

This report will outline the four depth analyses that will be investigated for the Community Healthcare project. Three of these analyses will focus on issues or opportunities that could be explored for the construction of this facility that could improve constructability, accelerate the schedule, reduce costs, or value engineer the process. The final analysis will be a critical research issue that will be further investigated for this thesis.

Analysis I | Precast Footings

A schedule delay, followed by several weather days proved to be a major challenge for the project team. The foundations and structure all had to be completed under cold weather conditions which significantly extended the duration of these activities. This analysis will look into the potential schedule savings that could be found by using precast footings in place of the cast in place design since construction occurs during winter months.

Analysis II | Prefabricate or Preassemble the Building Envelope

This project is currently utilizing temporary weather protection in order to complete the interior drywall and maintain the tight schedule. The exterior framing and skin are being installed through traditional means and methods. This analysis will focus on altering the construction means and methods to accelerate the installation of the skin and get the building watertight sooner. By either utilizing prefabrication or preassembly techniques, this analysis will determine if a less traditional method could provide added value or benefits to the project.

Analysis III | Masonry LINAC Vault

The linear accelerator (LINAC) vault was added to the core and shell GMP package fairly late in during design. The system that was selected was a standard concrete wall and ceiling assembly. By selecting this system, the vault had to follow the completion of the building structure versus being tied in. In the healthcare industry, many owners and medical suite designers are opting for masonry LINAC vaults over concrete. Due to the benefits masonry LINAC vaults can provide in cost savings and constructability, this analysis will evaluate which assembly, masonry or concrete, would provide the best value for this project.

Analysis IV | Virtual Mockups

This project has experienced several change orders due to late design changes. The change orders reflected the distinct wishes of the primary tenant, who understood the value these changes would provide to the operation of their facility. However, this analysis will look at potential technologies and specialty tools for creating virtual mockups that could help assist in discovering the design changes earlier.

Analysis I | Precast Footings

Problem Identification –

The original GMP schedule for the Community Healthcare project had to undergo a revision in October 2014. Construction was delayed by almost five months due to litigation on the land. The original issuance of the Notice to Proceed was set to be May 5, 2014 and was instead revised to be September 29, 2014. Additionally, the finish date was pushed to January 26, 2015 instead of the original completion date of June 2, 2015. The NTP date revision accounts about a five month delay; however, the finish date was pushed about seven months back. This remaining duration was largely attributed to weather days associated with the cold weather concrete of the foundations and the building concrete.

In the earlier GMP schedule, the foundations were scheduled to begin in mid-July 2014 and finish in early September with a total duration of 39 days. Instead the revised schedule had these same activities beginning in late November 2014 and finishing in late January with the goal of meeting the same 39 day duration. Instead, according to the July 22, 2015 schedule update, the foundations actually took 47 days and occurred from December 15, 2014 to March 10, 2015. Additionally, the building concrete activities including form and pour the slab on grade and elevated decks were originally scheduled to occur from late September 2014 to early December 2014 and last 51 days. The revised GMP had the building concrete occurring from mid-February to late May with a duration of 69 days. However, in the most current schedule update, which showed 51 weather days, the building concrete is now beginning in mid-March 2015 and going until late June 2015 with a duration of 54 days.

Background Research –

With the schedule being a driving factor for the tenants, looking to open their medical suites to the community as soon as possible, the ongoing schedule delays from weather days continue to push this opening day back. While the DPR team is doing their best to complete this project on schedule, they obviously have little control over the weather in their region over the past year. Cast-in-place footers were originally selected since they were the most cost effective foundation system. Additionally the original GMP had the footings being poured in mid to late summer. However, when the GMP schedule was pushed the footings were now being poured during cold weather and into potentially frozen ground.

Precast concrete is increasingly being used around the world as it continues to be recognized as a major schedule accelerator. Especially useful in simple structures or repetitive structures, precast concrete, if properly installed can not only accelerate the schedule, but also improve safety and quality. The Mid-Atlantic region has an abundance of construction projects, which ultimately puts this project in a location where there are several contractors who would be able to produce precast concrete members. The current footing design calls for fourteen different footing sizes for a total of fifty-seven footings. Potentially some footings could be upsized as well to reduce the number of different footings sizes.

Potential Solutions –

This analysis would focus on investigating whether a precast footing system is a viable alternative to the cast-in-place footing system. In doing this analysis, the results will show whether or not the schedule is able to be accelerated and show the cost variation between the two systems. Based on these outcomes, a recommendation will be made as to which system possess the best value for this project given the client's drivers and expectations.

Using precast concrete footings will be primarily investigated as a means to greatly accelerate the schedule; however, this alternative system may only have a minimal effect on the schedule. Precast in generally is known to be more expensive than cast-in-place; however, depending on the equipment needed to cure the concrete, this cost variation may be not as significant. Further investigation of the feasibility of this system needs to be researched an analyzed as well. Just because on system may be quicker or more cost effective, it still needs to be determined if precast footings are feasible for a project such as this one. For instance, the logistics of delivering these footings based on if they can fit on a truck and meet the road weight limit needs to be analyzed. Many of the larger footings may need to still be cast-in-place. Additionally, this system will be evaluated for the point at which precast footing would be beneficial.

Methodology –

Research

1. Research case studies that have used precast footings.
2. Research local vendors in the Mid-Atlantic Region.
3. Research the cost to implement this alternative.
4. Research the time it takes to procure precast footings.
5. Research the limitations and requirements of transporting the footings based on the laws of the road.

Feasibility Study

1. Determine the proximity of the precast warehouse to the site and the transportation costs associated with these deliveries.
2. Determine a delivery sequence for the footings to be brought to site based on the limitations of a truck and laws of the road.
3. Evaluate whether the precast footings could be feasibly transported to site.

Technical Analysis

1. Perform a cost evaluation of the two systems including the total cost of the cast-in-place system with the increased duration and added equipment versus the precast system.
2. Create a schedule for the alternative precast system to determine if the schedule could be accelerated and by how much.
3. Provide recommendations on the system that provides the best value based on cost, schedule, and feasibility.

Expected Outcomes –

Upon completing this analysis, it is expected that the precast footings will show considerable potential to accelerate the schedule. In comparing the cost, the cast-in-place footings will probably remain the cheaper option, but the goal is to find a reduced variation in the cost of the two systems after resolving all of the issues associated with cold weather concrete. With precast systems continuously being used more and more, this system alternative should be a feasible alternative, the question will just remain if this system is the best value. However, if these assumptions are correct, this analysis should be viable.

Analysis II | Prefabricate or Preassemble the Building Envelope

Opportunity Identification –

The façade system for this building was greatly value engineered to determine the most cost effective design. Ultimately, the final façade design had substantially fewer metal panels and curtain wall components than Perkins +Will had originally hoped for. Instead, many of the metal panels were replaced by brick veneer and the curtain wall with storefront windows or ribbon windows. Ultimately to maintain the schedule, temporary weather protection methods had to be put in place for several months so that the project team could install and finish drywall. This sequence is often avoided because installing drywall and electrical conduit in a building before officially watertight is more risky and difficult to maintain. To help remove this risk from the contractor, this analysis will look at the potential to get the building watertight sooner. By accelerating the skin of the Community Healthcare project, this building could continue with interiors without the need of temporary dry-in methods.

Background Research –

Preassembly and prefabrication of exterior framing and sheathing are increasingly being used on projects versus traditional installation methods. This facility utilizes fairly traditional construction means and methods for the majority of project. As detailed in Technical Assignment II, the skin for this project includes cold formed metal framing with gypsum sheathing. Not only are there local warehouses that could prefabricate this system, but additionally there is ample laydown area onsite for this assembly. By prefabricating this assembly, not only could the enclosure be accelerated, but also the workers could benefit from increased safety by use of this method.

Another potential method for assembling the building's skin is in preassembling sections of metal framing and sheathing onsite then installing these completed sections on the building's perimeter. Since there is ample space onsite to complete this task, the framers could benefit from creating these assemblies since their fall risk would be reduced through this method. Preassembly has also often proven to be quicker than building the assembly directly due to simpler constructability of the assembly since the area would have better accessibly.

Potential Solutions –

This analysis will focus on changing the current traditional method of installing the exterior wall to one in which the assembly is either prefabricated offsite or by preassembly onsite. By changing the construction means and methods for building and installing the exterior wall assemblies, there is the potential that the construction of this system could significantly improve the safety of the framers. Additionally either of these methods could accelerate the process of drying-in for the building.

Consequently, changing the current method could significantly increase the cost of producing this assembly. By modifying the traditional technique to one of the alternatives, the schedule may not be impacted enough to be worth any additional cost that could be associated with the alternative.

Methodology –

Research

1. Research the use of prefabricated exterior wall assemblies.
2. Investigate potential assemblies used in prefabricated skin systems.
3. Research situations preassembly onsite was used over the traditional method of installing directly to the building.
4. Evaluate whether to pursue prefabrication versus preassembly technique.

Technical Analysis

1. Establish a cost comparison of the traditional method being used and the selected alternative method.
2. Determine how productivity would be affected by changing methods.
3. Investigate the schedule impacts the alternative system would produce.
4. Consider safety of one system over the other.
5. Provide recommendations on which means and methods provide the best value to the project based on the investigated factors.

Expected Outcomes –

This analysis is expected to show that switching to an alternative method will reduce risk and increase safety to the project as a whole. Cost of prefabrication will probably be more than the traditional method being used. However, the cost to preassembly could potentially be the same if not less since increased productivity may reduce labor costs. Ultimately while productivity and schedule of the system installation is expected to be reduced, these alternative system may not accelerate the overall project schedule based on the processors and successors of the skin system. Additionally since temporary weather protection was used, the project was able to move forwards without the final dry-in, therefore, the question remains of whether or not this analysis has the potential to accelerate the schedule.

Analysis III | Masonry LINAC Vault

Problem Identification –

The linear accelerator (LINAC) vault was originally not including in the programming of this facility. However, upon the request of the primary tenant, the LINAC vault was added to the scope of work for the core and shell package but paid for and furnished by the tenant. Since this facility would ultimately include a large outpatient cancer care center, the primary tenant decided that this equipment was necessary to the programming of their new facility. The LINAC vault design along with the design of the other medical equipment rooms were contracted directly to a separate firm instead of Perkins +Will. This specialty firm selected a standard concrete assembly for the vault. This design requires a minimum 4' thick concrete walls and up to 7'-6" thick to prevent radiation from the machine from leaving the chamber. This layout is shown in Figure 1 left.

While the addition of this equipment does not sound like a major issue, at the time this change was made, the structure of this facility had already been decided upon. During early design, a structural steel frame system with elevated concrete decks was selected since this is the cheapest system for this area of the county. However, since this selection was already made the LINAC vault would not be able to tie into the structural system of the main building. Ultimately, this meant that the two facilities would have to be constructed separately of each other and connected by the envelope. If the LINAC vault and the main building could have been built simultaneously, there is some potential to accelerate the schedule or work more efficiently.

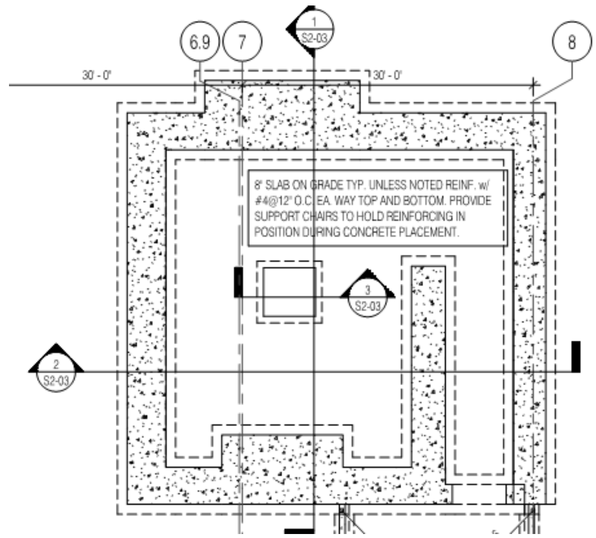

Figure 1 LINAC Vault

Background Research –

According to an article published by the journal *Healthcare Design* titled "Alternative Linear Accelerator Vault Construction," the industry is moving towards using more assemblies of high-density block and lead plate instead of the traditional thick concrete assemblies. This article sites benefits including thinner walls and ceiling thickness, simplified construction and renovation, and potential cost savings of this alternative masonry system. This system has the potential to work in this area due to the large number of masonry companies in the Mid-Atlantic region of the country. Additionally, this masonry assembly poses a problem for areas of high seismic activity; however, seismic is not a major concern for region this project is located. For all of these reasons, this masonry system could be further investigated as alternative to the current concrete design.

Potential Solutions –

By implementing a masonry system in place of the concrete LINAC vault design, an analysis could show this system would provide benefits in constructability and cost as mentioned in the article in *Healthcare Design*. There are a substantial amount of labor costs associated with the construction of the concrete vault, which may be more or less than the labor costs of a masonry vault. The cost of the large quantity of concrete material adds up as well in the original system. Additionally, there is a potential this system could accelerate the schedule by creating integration between the main building's structural system and the LINAC vault. However, there is the possibility the current system is the most cost effective. Since the LINAC vault is not on the critical path, there is a chance that the schedule will not be accelerated.

The masonry system may not integrate with building structure either. This analysis will seek to determine which system for the LINAC vault is best for this particular project.

Methodology –

Research

1. Research thoroughly masonry versus concrete LINAC vault assembles.
2. Determine why the concrete system was chosen for this project.
3. Understand how the masonry system would have to tie into the building.
4. Investigate the cost, constructability, and production of the associated systems.

Technical Analysis

1. Create a cost comparison of the two systems.
2. Determine if the schedule could be modified or re-sequenced to accelerate the schedule.
3. Provide recommendations on whether the original design or the masonry design would be the best assembly for the LINAC vault.

Expected Outcomes –

This analysis is expected to prove that a masonry vault is a better system than the current concrete design. If these assumptions are correct, the masonry system should prove a cheaper and similar way to construct the vault. Since the current design is not on the critical, it is unexpected that the alternative system will show great benefits to the schedule or sequence of the job. However, the industry is moving towards masonry systems for many reasons so this analysis could provide a better system for the LINAC vault on this project.

Analysis IV |Virtual Mockups | Critical Industry Research Topic

Problem Identification –

This project similar to many other medical facilities have experienced a series of change orders related to late design changes initiated by the tenant. The tenant's primary concern is for the best flow for the operation of their new space. As with typical medical facilities, late decisions on medical equipment typically leads a constant anticipation to have some associated change orders for the medical equipment. Despite opting to avoid any other BIM implementations besides the Revit design model, the Revit model is often enough to create virtual mockups.

Background Research –

During the interview with the project manager and superintendent, both highlighted change orders associated with late design changes to be as one of the major issues for this project. However, they would also agree that some of these change orders are to be expected on any healthcare project. Medical equipment is constantly improving, and owners obviously want the most current and up-to-date equipment for their new facilities. Going into a project with the expectation that change orders will occur is an interesting concept to investigate. On this project the tenant's primary concern was the flow of their different clinical spaces and were willing to allot any additional funds to make the space exactly how they want it. However, the question is could these tenants have seen these design issues sooner. By seeing the final design, in a more integrated viewer, could the tenants have understood the design better and made requests before they became costly.

Critical Issues Research Methods–

During the PACE roundtable this semester, Dr. Robert Amor gave a presentation titled "Life after the BIM Revolution," which revolved around his belief that the technology to improve the construction industry is available, but the industry still needs to harness the best methods for implementing these technologies. This presentation not only discussed this issue, but also highlighted some of the many technologies available today including virtual reality, game platforms, augmented reality, and social communication. This topic correlated with the Community Healthcare project since despite DPR Construction's reputation for continuously using BIM technologies and consistently redefining the standard of BIM implementation, BIM was not used on this project by the DPR team. Specifically related to medical room planning, virtual reality has been increasingly used as a design review method for end users. This allows the nurses and doctors to evaluate this spaces and the layout of equipment more effectively, especially having little experience in reading drawings. In today's industry, owners often still struggle to understand the design of their spaces by simply reading drawings, and therefore find themselves contributing to late design changes.

Goal of Research –

The goal of this research is to develop a guide for owners to better understand and illustrate the benefits that virtual mockups can provide to their projects. Just because companies are willing to experiment with new technologies, it is often tricky to convince an owner to fund the usage of these innovative methods on their project. Without previous use of these technologies, owners often struggle to grasp the value that these technologies can bring to their projects. It is difficult to translate potential cost savings into authentic metrics. Instead, researchers on these topics here at Penn State are focusing more on the conversations these technologies can stimulate during design reviews. This research will seek to determine these benefits on a series of selected virtual mockup technologies and create a guide of these technologies for owners to consider the added value versus cost.

Methodology –

Research

1. Further research the various change orders related to this project.
2. Research the various virtual mockup technologies available today.
3. Research case studies on the benefits of virtual mockups and usage in design reviews.
4. Hold interviews with at least three leading users of virtual reality today.
5. Research the current methods to evaluate the success of the mockup technologies.

Technical Analysis

1. Attempt to define change orders into categories of anticipated versus unpreventable change orders.
2. Select the most feasible virtual mockup technologies for the use of this project.

3. Determine a list of metrics for comparing the selected virtual mockup technologies for the usage on this project.
4. Present recommendations on the benefits and when to utilize of the best virtual mockup technology for this project.
5. Create a guide to determine which technology to implement and implications it would have on the budget.

Resources Required

1. Interviews with companies who have experience in virtual mockups.
2. Interviews with graduate students focusing on this topic.
3. Case study information concerning the use of different technologies.

Expected Outcomes –

The hope in producing this research is to determine the best virtual mockup technologies that reflect the tenant's drivers and goals for the project. These technologies will be evaluated on a series of determined metrics. This research should produce several virtual mockup tools, which will include the benefits and limitations of each. These technologies should be feasible for this project with only minor adjusts or minimum added costs.

Conclusions

The analyses preformed for this thesis will seek to utilize the knowledge received through the architectural engineering department to improve the construction of the Community Healthcare facility. By focusing on areas of difficulty experienced by the project team or looking forward by implementing innovative techniques, these analyses will investigate how alternatives methods could provide value. This value could come in the form of cost or schedule reduction, increased safety or quality, or any other forms of added benefits to the project. These analyses look at topics that were often unforeseen or unexpected as an opportunity for lessons learned, and other analyses as an opportunity to investigate newer methods or techniques. Ultimately, the goal of these analyses are to provide a series of recommendations for the construction means and methods that in hindsight could have added value to the project.

For the construction management thesis, four depth analyses and two breadths that relate the depths will be investigated in the spring semester. The four depth topics were outlined in this report and the two breadth opportunities can be found in appendix A. Analysis I will focus on the potential benefits of switching to a precast footing system in place of the current cast in place system since the project struggled with many weather days related to cold weather concrete. Analysis II will look at the opportunity of altering the current traditional method of installing the exterior framing and sheathing to a prefabricated or preassembled section. Analysis III will investigate the differences between the concrete LINAC vault assembly to a masonry vault assembly. Analysis IV includes the critical industry research topic of virtual mockups and the current tools being used to produce these mockups. Upon the completion of these analyses, recommendations will made provided to document these findings.

APPENDIX A:

Breadth Topics

Breadth Analyses

Analysis I – Structural Breadth

Analysis I looks at substituting a precast footings system in place of the current cast in place design. The breadth will focus on a structural issue associated with switching the two systems. One possibly will be investigating is how the soil bearing capacity will be affected by the installation of precast footings over the original cast in place system. This breadth will ensure that the soil has the bearing capacity to support the footing by this alternative method.

Deliverables for Soil Bearing Capacity

1. Calculations for the bearing capacity of the soil.
2. Support for or against whether or not the backfilled soil could support the footings.

Analysis III – Mechanical Breadth

Analysis III focuses on an alternative system for the LINAC vault instead of the current concrete design. By transitioning from concrete to high-density block wall, the thermal properties of the two systems could be altered. The topic is relevant to the exterior façade of the LINAC vault since the exterior will be a living wall and green roof. The thick concrete is expected to perform better in thermal performance since the solid system would not have any joints. This breadth will compare the two systems for thermal performance as another method to find the benefits and limitations of the two systems.

Deliverables for Thermal Performance of LINAC Vault Systems

1. Calculations supporting the thermal performance of both systems.
2. Recommendations for which system would provide the best thermal performance.

APPENDIX B:

Data Collection Tool

The interview below was conducted [DATE] with [NAME] of [COMPANY]. The answers below are paraphrased from the responses of the [NAME] and are not directly quoted from the subjects, however, they do reflect the intended content of their answers.

DATE:
NAME:
LOCATION:

Q1: Have you, your company, or your studies utilized virtual mockup tools?

A1:

Q2: How do you believe these technologies have improved your design review process?

A2:

Q3: What kinds of projects do you think would benefit most from these technologies?

A3:

Q4: What are some of the technologies your group have looked at?

A4:

Q5: Which technologies have proven most effective in conveying virtual mockups?

A5:

Q6: What would you need to implement and use these technologies on a project?

A6:

Q7: In terms of cost, what technology do you believe provides the best value?

A7:

APPENDIX C:

MAE Integrated Thesis

MAE Integrated Thesis

In order to integrate MAE studies into this thesis, concepts from AE 570 Production Management in Construction will be incorporated into these analyses. Specifically, the two analyses that have the most potential to benefit from these concepts are Analysis II and Analysis IV. Analysis II studying prefabrication or preassembly of the building envelope could utilize production tracking techniques from AE 570 to determine the system that would improve productivity. Some of these tracking techniques taught in AE 570 that could be used to analyze Analysis II include Spaghetti Diagrams, Gemba walks, Big Picture Mapping, and Ohno Circles. Additionally, Analysis IV looks at selecting the best tools for virtual mockups. Using lean decision making tools from AE 570 could assist in making this selection. Tools including A3 Thinking, House of Quality, and Choosing by Advantages could help to select the virtual mockup technologies that provide the most added value. Ultimately, MAE concepts will appear throughout this technical report as all of the concepts learned in these courses helped to stimulate the analyses investigated. However, AE 570 lean concepts provide benefits in investigating problems and determining the best methods for solving them. As this is the primary goal of thesis, these concepts should translate most effectively.