TECHNICAL REPORT III

The Mary J. Drexel Home Assisted Living Addition

Bala Cynwyd, PA

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Executive Summary

The purpose of this technical report is to identify areas of the Mary J. Drexel project that are good candidates for research, alternative methods, value engineering, and schedule compression. In order to identify the key candidates for research, careful analysis of potential acceleration scenarios, value engineering, and applications of critical industry issues were completed.

The most important driving factors throughout the whole project are project quality, cost, and safety. The project schedule was created in a manner that allowed these important factors to be achieved. This led the project to be driven by major construction activity and have a critical path span roughly the entire project. The first aspect of the critical path starts with the building foundation, then moves to the structural steel aspect, along with the building envelope then into MEP Rough-Ins and finally finishes and testing.

Many scheduling risks were associated with the schedule that could impact the completion date. One of them being coordination efforts that must be taken by general contractor to communicate with the Owner supplied site-contractor. Another risk is the prefabricated load-bearing structural steel system in which any flaws in the design could lead to substantial delays. Although schedule is not a major factor to the Owner, any delays will lead to extra costs. It is important to the Owner that these risks be mitigated to avoid any potential costs.

Although there may be some risks associated with the schedule, there are also simple and cost effective techniques and strategies that can possibly accelerate the schedule. The simplest of course is to re-sequence the schedule so trades can start working simultaneously with others and both wings start at the same time. Another method would be the use of more prefabricated systems.

Some of the major Value Engineering items accepted for the Mary J. Drexel project include structural changes such as changes in the roof deck and foundation walls. Other efforts include exterior stone veneer modifications and many efforts were made with the interior finishes. The Owner emphasized the importance of maintaining the quality of the project and anything that was believed to threaten this quality was not implemented. This is definitely the case for the high quality finishes of the project.

Lastly, critical industry issues were discussed at the Penn State 2013 PACE Roundtable. Some of the topics discussed included safety, information management, assembling cost effective functional teams, phasing decisions for retrofits, efficient delivery of facility management information, and multi-trade prefabrication. Some of the discussion topics such as information management and multi-trade prefabrication were researched to determine whether their implementation on the Mary J. Drexel project would be beneficial to the project.

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Schedule Acceleration Scenarios

As stated in Technical Reports 1 and 2, the driving factors that drove the Mary J. Drexel Project were project quality, cost, and safety. Due to these factors, the project schedule was created in a manner that allowed them to be achieved. The following sections detail key features, risks, and potential areas where the schedule can be accelerated.

Critical Path

The critical path for the Mary J. Drexel project encompasses a wide variety of construction activities. This path roughly spans throughout the entire project. Figure 1 below depicts the wide variety of activities that are on the critical path.

Figure 1 – Critical Path of Project Schedule

When the schedule for this project was developed, it was driven by major construction activity. The first aspect of the critical path deals with the buildings foundations. It begins with the installation of footings and CMU bearing walls. Underground plumbing and electrical rough-ins are also included and then the installation of the first floor slab on grade. The West Wing was the first wing to start, so the critical path was more focused on the East Wing as it started almost one month after the West.

Upon completion of the foundations, the next aspect dealt with the prefabricated structural metal stud wall panels. This aspect also includes the metal deck for the second floor slabs. As the metal deck is being installed MEP sleeves were placed. Due to the structural system being load bearing wall panels, once the deck was place shoring had to be put up before the second floor slab is poured. This did not allow for any MEP overhead work to start until the shoring was completely removed.

The next item on the critical path sequence is the completion of the building envelope. This is placed on the critical path because none of the electrical wire could be pulled until each respective building was enclosed. Also, none of the interior finish trades can get started either besides the light gauge metal framing until each building was enclosed.

Once the building envelope is enclosed, the MEP rough-ins in the ceilings and walls is the next item to be considered. This then leaves the interior finishes and final testing as the last aspect of the critical path.

Schedule Risks

The first scheduling risk to consider is that the general contractor must coordinate with the Owner's site contractor throughout the entire building process. This is important since the building foundation is the first aspect in regards to the critical path. Therefore, any coordination issues that develop in the beginning of the project will greatly increase the chances of the project being delayed.

The biggest scheduling risk on the project is the completion of the structural system. As indicated prior, the structural system is composed of prefabricated load-bearing wall panels. As with any type of off-site prefabricated material, any mishap or error in the design of the panels could cause major delays to the completion of the project. Once these panels arrive on site they must be designed correctly and installed precisely per the drawings. If a design flaw were to arise then the panels would need to be rebuilt and shipped back which will lead to a significant schedule delay and additional transportation costs.

Finally, getting the building envelope water-tight is another critical risk to the project. For this project specifically, the installation of the stucco system required an inspection of the metal lath before the scratch coat is installed. Subcontractor performance is definitely a consideration in ensuring that the installation of the lath is correctly according to local code.

Although schedule is not a major concern of the Owner, cost most definitely is. Any schedule delays always incur extra costs to the project so it is important that these risks be mitigated as much as possible.

Potential Schedule Acceleration Options

The simplest and cheapest way in which the project team could accelerate the schedule is through re-sequencing the entire project schedule. The current schedule is set up so that the East wing is delayed a few weeks after the West wing and that trades would start after another trade was finished working. This method was predominantly shown in the structural phase of the project. This allowed for the structural setting crew to install their work without any worry of another trade getting in the way. This is an easy opportunity for the schedule to be cheaply accelerated if necessary. Since the concrete slabs were poured in two pours, the erection of the structural wall panels could begin as soon as the first pour is cured and move on forward in this pattern. Similar options to re-sequence activities throughout the project schedule are available if the project team desires to reduce the schedule. All the techniques regarding the installation of each trade would be the same except for the fact that a little more effort would need to be considered in the coordination of the specific trades.

The other way the schedule could have been accelerated is by using different installation methods such as more prefabrication. A vast majority of the project is assembled in place and although this is standard, it is not the most efficient in terms of schedule durations. Having building systems assembled off-site in controlled environments then shipped to the construction site for placement is an extremely beneficial method to construction. The prefabricated load-bearing wall panels are a great example for this project. They allow for quick installation once delivered to site as they only need to be hoisted into their final resting position and connected to the slab and other wall panels as they are erected. The drawback of using other prefabrication methods for other building systems would be the high level of coordination that is necessary. Since BIM was not implemented on this project much other than for the MEP systems, this coordination may be difficult to manage. Although prefabrication may incur higher construction costs, the use of this method will reduce the total project schedule duration. The project team's main focus was on cost and quality, it was more beneficial to proceed without the higher costs associated with implementing additional prefabrication methods.

Value Engineering Topics

The most important aspect of this project to the Owner was overall cost. Many steps were taken throughout the project to ensure that the Mary J. Drexel project was built to the highest of quality at a relatively low cost. Value Engineering efforts were implemented that lead to this being the case for the Owner. Many Value Engineering items were considered and accepted for the project. Some of the more prominent items that were value engineered are discussed throughout this section.

Roof Deck

One of the first items taken into consideration to be Value Engineered was the original design for the roof deck. The original design called for an epic roof deck with concrete. Instead, the idea of using a 4-1/2" 18 gauge roof deck with an EPDM roofing system was proposed. The main reason this was considered was for budgeting issues. In order for this to be accepted however, confirmation was needed from the structural engineer that this alternate rook deck material would be able to handle the structural loading requirements. Replacing the Epic Deck with the new roof deck was in fact confirmed to handle the load requirements and thus lead to a collaborative team approach to reducing the overall cost and maintaining the quality and structural stability of the project.

Foundation Walls

Another structural related value engineering element that was implemented was the replacement of the originally designed perimeter foundation walls. Originally, the contract documents included cast-in-place concrete foundation walls throughout the entire perimeter of both wings. The idea to replace these foundation walls with fully grouted 12" CMU walls arose through the Value Engineering process. Having had used concrete foundation walls, the process would have been more labor-intensive due to the requirement of setting up formwork before being poured. Also, a poured concrete wall must be properly cured before any additional work may proceed for the structure of the building. Changes were made to the structural drawings to reflect the change. This change not only lead to reducing the cost of having concrete walls, but also helped the critical path and save time off the schedule since the structure can continue to proceed without having to wait for any concrete to properly cure. This is especially beneficial since the foundation work had started in the winter.

Stone Veneer

Using real stone for a project can become very expensive depending on the type of stone being used. In the case of the Mary J. Drexel project, it was decided that it would be more beneficial to use manufactured stone for the veneer in lieu of real stone. Although the Owner preferred real stone to be used on the project, an agreement was reached where a small amount of existing stone from the demolished buildings as well as stone found from the site would be used in combination with the manufactured stone veneer. This collaborative effort maintained the standard of quality the Owner had established and also helped reduce cost as well.

Finishes

As stated over and over again, maintaining the quality of the project is the most important aspect of this project. Budget issues always arise from time to time and changes must be made and accepted. The most cost beneficial items that were Value Engineered came from the interior finishes of the project. Some of the significant items accepted by the Owner included:

- Replacing the residential units custom casework with approved Armstrong Cabinets
- Replacing shower surrounds with cast marble wall panels
- Alternate spa tubs for Spa Rooms
- Using standard handrail in lieu of specified 3 piece railing
- Removal of all wallpaper; Paint all walls instead
- Replacing interior solid wood doors with composite wood doors

These changes allowed for cost savings as well for a pleased Owner with the quality of products being installed. Throughout the entire process, close communication was maintained with the Architect and Owner to ensure that all needs and goal are being met to the projects standards.

Value Engineering Items Not Implemented

Throughout the entire Value Engineering process, the owner emphasized the importance of maintaining the quality of the project. Although budget issues caused the Value Engineering process to begin, if the Owner believed that any option threatened the overall quality then it would not be implemented. Any structural changes that were confirmed by the structural engineer were accepted in the value engineering process. However, many of the visible finishes that were important to the Owner were not implemented through this process. Discussions and agreements were established to ensure satisfaction to the Owner. Some finish items such as changing the ceramic tile flooring in the resident bathrooms to vinyl sheet flooring and changing kitchenette countertops to a composite type from granite were not implemented due to the fact that quality was the number one consideration. Other items were out of the Owner's jurisdiction such as the exterior façade. Specially, the stucco portion of the façade. The Lower Merion Township Historical Commission would not allow EIFS to be utilized in lieu of stucco. The reasoning was due to the existing mansion having stucco, thus the new additions must have the same stucco envelope. Effective communication and planning allowed project team to consider as many value engineering items as possible and effectively design and build a project to the Owner's satisfaction.

Critical Industry Trends

2013 PACE Roundtable

The PACE Roundtable event is a great opportunity for Penn State Architectural Engineering faculty and students to gather with industry professionals and discuss current industry trends and issues related to construction. The topics discussed included safety, information management, assembling cost effective functional teams, phasing decisions for retrofits, efficient delivery of facility management information, and multi-trade prefabrication. Students were broken up into two sessions where they chose to join whichever topic they seemed most interested in. The roundtable then ended with smaller feedback discussion groups where students had the opportunity to meet more personally with industry members and discuss what was learned from the day.

Session #1: Information Management for the Workforce

This session primarily focused on the impact technology has on managing information at different levels of a construction project. A topic was brought up to focus on an industry standard for how information is delivered and find a better way to represent certain items. Such items include design drawings; More time seems to be spent with designers annotating and documenting drawings than actually designing. There should be a better way of presenting materials to all members of a project team.

The availability of all the different technological tools may seem great, but this leads many construction management firms to develop their own custom system of tools. This results in much time being spent on training subcontractors and others during kickoff meetings and training sessions. This custom development may have these firms resist change due to the fact that they are knowledgeable with their own system and feel it is more effective than what others may offer.

There is definitely a cultural shift that has risen for electronic information. Having a technological barrier between project team members can cause miscommunication and essentially lead to problems during the project. Ideas were mentioned about having a better user interface for teams and also this concept of reverse mentoring. Many young professionals are comfortable with using the technology while older professionals are more comfortable with having their printed set of drawings in front of them. Having a process such as reverse mentoring is beneficial in that while the more experienced professional is mentoring the young professional through the beginning of their career, it should be important that the young professional in turn helps the experienced professional with any technological barriers they see arise.

The current industry is definitely seeing a cultural shift with new technology. The technology and age barrier will diminish with time.

Session #2: Multi-trade Prefabrication

The multi-trade prefabrication process allows multiple building systems to be constructed in a controlled environment off-site while other building systems such as the structure are being constructed on-site. There are many projects that have repetitive elements that are well suited for this process. The use of multi-trade prefabrication is a process that revamps the building delivery process and produces high quality projects more quickly, safely, and cost effectively.

BIM is the enabler of prefabrication and is all depends on the contract and project type. Design of prefabricated units are developed in the beginning stages with all building system trades heavily involved in coordinating and setting tolerances.

One of the largest concerns that was brought up regarding the use of multi-trade prefabrication is actually getting paid for the work completed. It can be difficult to receive payment for a module that is completed but is not necessarily installed out on the actual project yet. Other concerns include:

- Site restrictions
- Trucking to and from site and laws associated
- Permits and hoisting
- Liability

Many concerns can be mitigated with the increased level of pre-planning that takes place with the contracts and such.

Some common criteria discussed for systems and assemblies to prefabricate included MEP common racks, bathroom pods, exterior wall panels, precast concrete panels, and mechanical penthouses. As stated earlier, BIM is the enabler of prefabrication and will allow the production of prefabricated building components. This all leads to a reduction in overall cost and time of the project delivery while increasing quality.

***See Appendix A for notes taken during 2013 PACE Roundtable**

Appendix A: PACE Roundtable Submission Form

Feedback from Industry Roundtable

Session #1

Topic: *Information Management for the Workforce*

Research Ideas:

1. How efficient was the delivery approach for the project due to all the changes that arose throughout?
    a. Could there have been improvement if a different delivery approach was selected?
    b. The MEP systems were design build, but other parts were design-bid-build. What is the whole project was design build?
2. What would the benefits have been if there was a universal 3D model for all systems of the project instead of just having MEP coordination?
    a. Since the steel structures comes in prefabricated panels, could it have been better to use the 3d model to design these panels so window openings were correct.
    b. Compare advantages and disadvantages
        i. Cost associated with coordinating
3. Focus on an information standard for the industry
    a. More time designing / less time documenting and annotating
    b. What would be a better way to represent the design?
    c. Subcontractors always end up re-drawing documents which adds extra time.
        i. To what level should the design engineer design in the first place?

Session #2

Topic: *Multi-Trade Prefabrication*

Research Ideas:

1. Would the use of multi-trade corridor racks be beneficial on the Mary J. Drexel project?
    a. Because the MEP systems were design-build this could have been beneficial in reducing time and possibly cost of labor.
2. Look into the possibility of maybe having the pre-fabricated load bearing metal stud walls possibly come to site with other trade systems installed as well?
    a. Could potentially come with sheathing already installed (on exterior wall panels) so building could be dried in sooner. Consider leaving tolerance to allow panels to be connected.
3. Look at different types of modularization/multi-trade prefab:
    a. Bathroom pods; prefabricated exterior panels (as mentioned above), roof truss prefabrication.
4. Could the Mary J. Drexel been a modular project?
    a. Hybrid of site-built construction and modular components

Industry Member Discussion

Industry Member: Chuck Tomasco

Key Feedback:

Which research is most relevant to industry? What is the scope of the topic?

1. Information Management
    a. Impact of the delivery approach
    b. Offered the idea to explain why technology would be used on small scale projects and not just large projects.
        i. Advantages and disadvantages
2. Multi-trade prefabrication
    a. MEP Racks
        i. Great for use in hospitals and buildings that have similar layouts especially for patient rooms.
        ii. This could definitely be a possibility for the Mary J. Drexel project due to the resident rooms being all the same and sharing a common corridor similar to hospital layouts.
3. Systems Integration
    a. Any systems that involves two or more different systems interacting with each other
        i. Perfect example would be a security system with doors.
            1. Wandering Alert System for Senior Living Facilities

Suggested Resources

What industry contacts are needed? Is the information available?

1. Chuck Tomasco, Truland
2. Dan Burns, Southland Industries
3. Jason Reese

Appendix B: Problem Identification & Technical Analysis Options

Problem Identification & Technical Analysis Options

Problem Identification

This section will discuss some of the problematic features of the Mary J. Drexel project that have been discovered through the preliminary research from the three technical reports. These problematic features will contribute to identifying potential technical analysis topics that may have the potential to improve the overall project success. The potential project improvements are detailed in the following sections below.

Analysis Topic #1 – Project Sequencing

The first potential improvement for the Mary J. Drexel project involves the sequencing of activities on the project schedule. As stated in Technical Report 3, many major construction activities were scheduled with one following another without any overlap. Although schedule was not of high importance to the owner, the overall project cost was of significant importance. The purpose of completing a technical analysis of re-sequencing the project schedule is to shorten the overall project schedule. Thus, minimizing the total project costs associated with the general conditions of the project.

In order to complete a detailed analysis of how the sequencing of the project can be improved, the first step will be to analyze the entire project schedule in depth. After identifying the potential areas where sequencing may be improved, research will then be performed to ensure that any alterations to the schedule will be possible in terms of the potential building systems that may be affected. If the systems do not allow the alterations to be made, then they will be left as scheduled previously. After the project is rescheduled according to the alterations to the sequencing, it will be reevaluated. When reevaluating the new project schedule, the original general conditions costs will be compared to the new costs to determine the amount of savings that would have been saved if the project schedule had been sequenced differently.

Analysis Topic #2 – MEP Prefabricated Corridor Racks

Another potential improvement for the project involves the prefabrication of MEP Corridor Racks. Due to schedule delays there was a need for an increase in manpower and productivity in regards to the MEP systems installation. Although these delays were not a direct result from the performance of the MEP trades, they were forced to employ extra crews during the week and start overtime work on the weekends in order to meet the schedule. The extra efforts could have been avoided if the MEP systems were fabricated at an off-site warehouse and then transported to the construction site. The main focus of implementing MEP prefabrication will be placed on common corridor racks for both wings since they are both identical. This will result in cost savings from reduced labor and the prevention of overtime. Other results will include increased productivity, safety, quality, and efficiency of materials.

The analysis will start on how BIM can be used to facilitate prefabrication techniques. This is beneficial specifically for this project because the MEP systems were the only systems that BIM and clash detection was used for. Key contacts in the industry from Southland Industries and Truland will also be contacted on the prefabrication techniques. Fabrication time and installation times will also need to be assessed and compared to the durations from the original project schedule to evaluate if schedule savings will occur. There may be extra costs associated with the prefabrication of the systems, but these can easily be covered by the potential cost savings from schedule reductions and less labor.

Analysis Topic #3 – Green Roof System Implementation

Although many value engineering efforts were made to benefit the owner, very few sustainable techniques were considered that could have provided more financial benefit to the owner in the long run rather than short term. The elimination of the Epicore Roof and the implementation of a steel roof deck did allow for a significant cost savings to the owner, but the only reason this was done was just to reduce the initial capital cost of the project. The consideration to add a green roof system provides the owner with other economic advantages such as energy savings, tax incentives, and cost savings from increased storm water retention. Not only will a green roof system be beneficial for the owner, but for the building occupants as well. Since the occupants of this project will be elderly persons, noise reduction is another great advantage for the green roof system. This is especially beneficial since Belmont Avenue is a highly traveled road throughout the entire day.

In order to complete a detailed analysis of how a green roof system implementation will be beneficial to the owner and the project, the first step is to research the types of green roof systems and choose which one would be more suited for the project. When evaluating the current system and green roof system, initial costs and a life-cycle cost analysis will need to be performed. Energy efficiency associated with each roof system will be analyzed as well. Two breadth opportunities will be met as well by analyzing the impact on the mechanical and structural system of the project. Another breadth opportunity that could be met as well is an acoustical breadth that evaluates noise attenuation of the rooftop air handling units between the current design and green roof system.

Analysis Topic #4 – Alternative Delivery Method (IPD)

The current delivery method for the Mary J. Drexel project is a mixture of Design-Bid-Build and Design-Build. During the design phase, Wohlsen, the general contractor, was brought in to Design-Build the MEP systems while the other buildings systems were being designed by the Architect. Throughout the construction process many miscommunication issues and problems with the drawings arose causing delays from waiting for RFI responses and change order approvals. Had there been early involvement from the trades many of the problems could have been mitigated and communicated effectively to the entire project team. Design changes were also made that required a lot of value engineering efforts that required compromising on a lot of the high quality finishes that the owner did not want to lose.

The goal of this analysis would be to determine the potential benefits of using an integrated project delivery (IPD) method as opposed to the current delivery method. IPD is a delivery method in which all prime players in the design and construction process are fully involved in the earliest stage of the project. In order to complete this analysis, a comparison between the current method and IPD will be performed. The two different methods will be analyzed by discussing advantages and disadvantages of each method and creating process maps to help illustrate differences especially in communication and coordination throughout the project duration.