Technical Report 3

Alternative Methods Analysis

This report was compiled to identify areas of the project that would be good candidates for research, alternative methods, value engineering and schedule compression.

11/15/2013 | Jeffrey Martin | Advisor –Dr. Robert Leicht | Atrium Medical

[Executive Summary]

This report has been compiled to identify the areas of Atrium Medical Corporation's new headquarters facility that would be good candidates for research, alternative methods, value engineering and schedule compression. The primary components of this report include; Schedule Acceleration Scenarios, Value Engineering Topics, Critical Industry Issues and Feedback from the Industry Roundtable. These features will be discussed throughout the report in greater detail.

The new 101,200 SF, one story addition, being added onto the already existing 100,000 SF two story building, is set to be completed in June of 2014. Based on construction tasks throughout this timeline, Hutter has faced some challenges that have, at times, increased the project duration. They've also solved some issues that have decreased some of the specific tasks durations. Overall, Hutter has determined that the total project duration, with individual task duration increasing and decreasing, is unaffected. With the systems in place, Hutter has dictated that there are no significant areas that would allow the total project duration to be decreased.

There were multiple areas of the project where Hutter had to collaborate with its team and the subcontractors as well, to develop solutions to issues that arose in the fields as well as in the design work. These issues include; the kitchen area roof structure, the fan filter modules, the building envelope system and the slab on grade reinforcements. Throughout these challenges, Hutter has had to determine multiple solutions to a single problem, which would allow them to determine the most cost effective and efficient system to put in place.

Also throughout this report you will find information regarding the two info sessions that each thesis student was required to attend. These info sessions were designed to provide the thesis students with ideas about research topics they intended on delving into for future analysis. The two discussion I had attended include; Safety-Prevention through Design and Criteria and Drivers for Effective Multi-Trade Prefabrication and Modularization. The Safety- Prevention through Design initiative was set forth to provide information about current industry issues with implementing safety plans in the design phase of construction, to help prevent future hazards. The Multi Trade Prefabrication and Modularization discussion revolved around the benefits and issues associated with implementing a prefabricated system on a construction project.

Finally, the report is concluded with the feedback from the industry roundtable meeting, as well as my personal response to the discussion with one of the industry professionals. During this discussion, Jason Reese of Balfour Beatty Construction was able to help provide me with ideas for my thesis analysis that I will use to help compile my final proposal. This will act as an overall layout and structure for the work that will be completed next semester.

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[Schedule Acceleration Scenarios]

As mentioned in the Technical Reports 1 & 2, Atrium Medical Corporations Headquarters' project is a little over one year in length. The owner for this project did not emphasize the necessity of an in-depth schedule, as they have a strong working relationship. The schedule for this project, being just over 100 tasks, was designed to incorporate contingencies within each task's duration and provide the owner with an overall progression of events. However, even though the schedule is not extremely detailed, the project's completion date is strict and must be met. This projects critical path can be summarized into the major categories outlined in Figure 1 below.

Critical Path

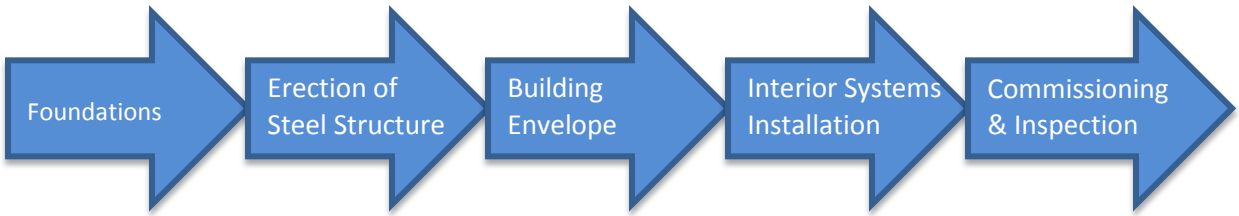

Figure 1: Critical Path Summary

Figure 1 above demonstrates the major tasks involved in any building construction project and generally only differ based on the specific types of systems being installed. The construction of this project spans a little over a year, which began in May of 2013 and is intended for completion in June of 2014. The foundations of this structure consist of cast in place piers on top of concrete footings to support the superstructure above. The footings along the exterior are joined together by strip footings and topped with four foot tall foundation walls, unless otherwise noted. The construction of the foundations took approximately 10 weeks due to the fact that they consist of all cast in place parts, which required a lot of time to form, pour, cure and finish.

The next major task in this project is the erection of the steel structure, which took around 9 weeks to complete. As mentioned in the previous tech reports, since the building is only one story, the building isn't being constructed in phases relative to construction, and are rather separated based on site layout. Therefore, the structure is assembled based on the entire building layout, from the bottom to the top. First the columns are erected with lateral braced frames in certain areas, then wide flange roof beams, followed by roof joists. The interior of the warehouse space also contains a mezzanine for lower roof access.

Following the erection of the steel structure is the installation of the building enclosure systems. This process will take approximately 18 weeks and is currently being installed, with about 4 weeks completed. The building enclosure is comprised of insulated metal wall panels that wrap the entire perimeter and roofing system installation. Once the exterior is completed, the interior systems are to be installed, which will take the longest time of all at around 35 weeks. The reason this system will take so long for installation is not only because it encompasses all the interior systems (i.e. MEP systems, sprinklers, cold form framing, GWB and insulation etc.) but also because some of the areas require special care when sealing. Once completed the building is

set forth to be commissioned and inspected before it can be turned over to the owner. This process will take approximately 10 weeks, including the final project cleanup.

Greatest Risks

One of the greatest risks that Hutter Construction has been experiencing throughout this project is defining the owner's manufacturing requirements. As mentioned in technical report 1, Atrium Medical Corporation is a manufacturing company that develops small medical parts for various medical facilities throughout the nation. Being that they manufacture medical equipment, they require that some of the spaces in the manufacturing department need to be designed to certain standards. These "clean rooms" need to be sealed based on Atriums Requirements, which are depicted based on FDA requirements. This implies that the mechanical and electrical work needs to adhere to FDA regulations. The mechanical and electrical subcontractor have had the opportunity to develop a working relationship with the owner, which provides them with the ability for direct contact should any confusion arise.

These requirements are particularly stringent in relation to the pressure and temperature requirements. The electrical contractor is required to install the necessary equipment that can monitor both temperature and pressure, and the mechanical system needs to be able to adjust to these demands. The clean rooms need to maintain a specific temperature, like 68^{o}F +/- 2^{o}F, and when this demand isn't met, an electrical alarm system goes off to signal that certain equipment may need to be replaced or repaired. These monitoring systems are also required to maintain specific pressures in the clean rooms, which gradually drops as you leave the clean room spaces. The reason having these requirements acts as a risk for the project is because these requirements are constantly being updated by the owner, which at times may conflict with the work already installed. With things like this always changing, the demands from the owner become difficult to follow, and the schedule can possibly become delayed.

Project Acceleration, Costs and Techniques

After speaking to the Project Manager from Hutter Construction, David Lage, he described that there are no key areas to help accelerate the schedule. The schedule developed for this project is intended to be utilized to the fullest and all the time allotted for each task will be utilized completely. He mentioned that because the way the building is structured, there would be no opportunities to increase the schedule, unless the employees were required to work overtime and double shifts. Even though the schedule can't be accelerated drastically, Hutter Construction has been making its attempts to eliminate some time from the total duration. One thing Hutter has done was to replace all of the welded wire mesh and rebar in the slab on grade, which can be seen in

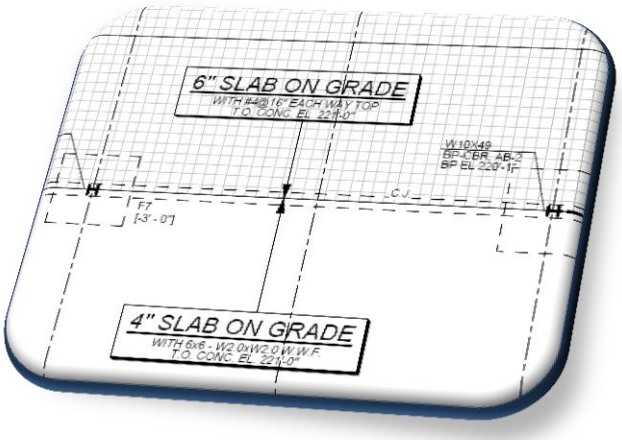

Figure 2: Snip from Arch. Drawing that depicts the original slab construction.

Figure 2 to the right, with synthetic macro fibers. This effort not only decreased costs for the project, but also accelerated the schedule slightly. However, with the constant changes from the owners manufacturing system requirements and their added time to the schedule, small efforts such as replacing the rebar with Strux fibers, seen in Figure 3 to the right, may only balance out with the additional time.

Figure 3: Strux Fibers courtesy of WR Grace

[Value Engineering Topics]

As mentioned in Technical Report 2, there were some areas of construction that involved the implementation of value engineering in order to determine the most efficient and most cost effective system. Some of these areas have greater emphasis than others, but are all intended to develop the best system for the owner. As mentioned in the previous Technical Reports, Atrium Medical is looking for a building that prides itself with quality and efficiency. In order to achieve such quality and efficiency, Hutter Construction had to delve into some of the original designs and make changes to find a more efficient and effective system.

Kitchen Area Roof/Floor System

The kitchen area of the existing building became the key location for where the existing building and new addition will be joined. This part of the existing structure is located below grade and had a roof system composed of precast concrete planks. The initial issue of concern was whether or not to utilize these planks as a suitable substructure for the intended concrete slab to be poured over top. The initial idea was to leave the planks as they were, but in order to do so, they'd need to do some investigating.

Hutter Construction did some research to determine the loading characteristics of the planks based on their manufacturer's details and age. Once these values were found, Hutter realized that a fill material would need to be added between the base of the poured concrete slab and the top of the planks. Their first system proposed was to utilize the existing planks with a gravel fill on top. Hutter then determined that the gravel fill would add too much dead load on the planks and that they would need to be supported by steel columns below. Another idea proposed was to add rigid foam insulation as a fill material on top of the planks, but because the loading of the slab above, reinforcing would also need to be added below in the form of steel columns.

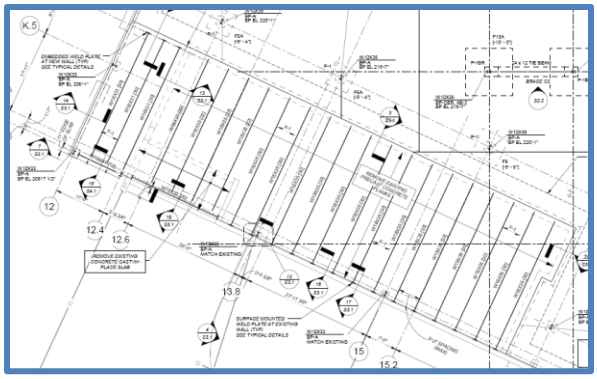

Figure 4: Structural Steel Layout at Kitchen Area of Existing Building

After speaking with Atrium Medical, Hutter decided they should develop a system that would open up the space rather than have support columns contaminate the area. This led Hutter to design a system where they would raise the existing foundation walls by pouring another layer of concrete on top of them to support a steel floor system, shown in Figures 4 & 5 to the

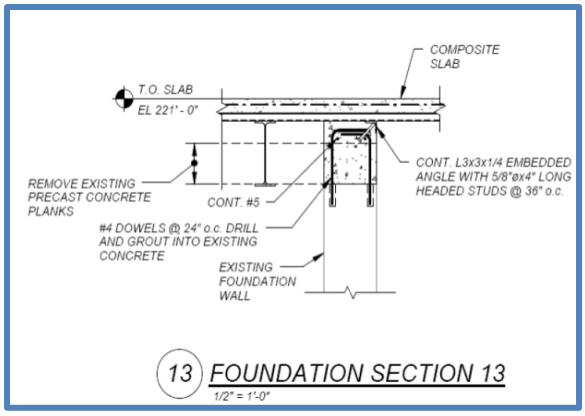

Figure 5: Detail of New Foundation Wall Poured on Top of Existing Foundation

right. By doing this, they eliminate the need for a fill material, as well as open up the space below. This became the system of choice and even though it was more costly, it met the owner's desires and is an overall more effective system as it eliminates the possibility of the existing system failing.

Reinforced Fibers in Slab on Grade

The cast in place slab on grade was originally designed to be separated based on building use. The manufacturing area was to have a 4" slab reinforced with welded wire fabric. The warehouse area was to have a 6" slab that would be reinforced with #4 rebar each way and welded wire fabric. Hutter realized that the reinforcements for this system were impractical as they were too costly for the load demands and the labor to install them would only be more intensive than necessary. From here, Hutter determined that the best solution would be to completely remove the steel reinforcing from the slab and to replace it with synthetic macro fibers. They decided to use WR Grace's Strux Fibers as their product of choice, as it met the entire load demands and cost much less than the steel reinforcing system.

Building Envelope System

This area of the project went under intense consideration, as the method of hanging the insulated metal wall panels was not properly defined in the architectural documents. With this in mind, Hutter proposed two methods to help solve this issue. The first idea was to add cold metal framing all along the exterior of the building. With this framing in place, the insulated metal wall panels would be fastened to the framed walls directly. This system, while effective, was too impractical as the costs were too extraneous. The second proposed system was to add intermediate columns between the buildings structural columns, and mounting horizontal HSS steel tubing to the exterior of the intermediate columns. The insulated metal wall panels would then be fastened to the HSS steel tubing. This system was overall a cheaper alternative and didn't add any more or less efficiency than the cold form framing, so this became the system of choice.

In addition to these two systems, Hutter also proposed the idea where they would possibly construct a reinforced CMU wall along the perimeter of the warehouse area. The reason for this being that a CMU wall would be much more durable against any accidents that may occur due to large machinery (forklifts). This system appeared feasible as the durability factor was quite appealing, but the costs of this system seemed to heavily outweigh its benefits in comparison to an all metal wall panel system.

Fan Filter Modules & Hanging System

The primary issue here was how to properly hang the fan filter modules located throughout the various spaces of the building. This became an issue because each of these modules carries a decent amount of weight and cannot be supported by a simple lightweight metal grid system. Therefore, Hutter devised multiple methods to hang these pieces of equipment to determine which system would be the most effective. In order to properly design these systems, Hutter had to confide in a clean room consultant. This consultant helped them to determine three systems.

The first system proposed was a structural grid system made from steel framing. This system would be able support the fan filters as well as the lighting fixtures, as they'd be on the same level. The next system would be similar to the fist as it would utilize a grid layout, but it would be constructed entirely of uni-strut channels. This system would also be able to support the lighting fixtures. The final proposed system was to just use a random assortment of unistrut channels. This final decision became the primary choice as it was much less costly and allowed better coordination with the MEP systems.

Also, Hutter determined that there were too many fan filter modules in the original design. The original modules were 2' x 4' and most of them were located near one another. Hutter decided to go with the 4'x 4' modules instead as it was more cost beneficial to have half the amount of filters at only a slightly greater cost per 4'x4' versus the 2'x4' module.

[Critical Industry Issues]

Breakout Session 1: Safety – Prevention through Design

During this session, my fellow classmates and I and the industry professionals, came together to discuss how safety could be ensured through implementing safety plans during the design phase. Implementing safety plans is not typical in the design phase but is becoming more and more apparent as the desire to lower occupational hazards has increased. The reason for this is primarily because the design team generally assumes that the construction team should take care of the safety issues. There were many ideas that were proposed to help alleviate these issues, such as; develop a culture of safety, prefabrication, contractual language, college safety programs etc.

It was surprising to see how much care goes into safety in the construction industry. To know that every step is being taken to help ensure a safe jobsite and post construction building is simply amazing. The PACE roundtable session is just one example of how industry members come together to discuss different ways to make a safer construction site that they will use on their own projects. One specific topic I enjoyed discussing was the possibility of implementing a safety team throughout the design phase as well as the construction process. I feel that if a safety team could be present during the design process, they would be able to foresee any issues that may arise in the field as well as post construction. Another topic that aroused my intellect was the idea of implementing a rule of thumb for all construction projects. This rule of thumb would essentially be a set of guidelines that would be required to be applied to each projects design. By doing this the occupational hazards in the field as well as post construction will be minimized and hopefully prevented.

It would be very beneficial to my project if the two ideas discussed above could have been implemented on Atrium Medical Corporations Headquarters. These ideas stress the importance of implementing safety plans in the design phases of a project. Plans like this will help seriously reduce the risks of occupational hazards. Since Atrium Medical's new facility has already begun construction, the implementation of a safety plan in the design phase is not possible. Even with this at hand, a design team could be utilized to help see the construction throughout its life until completion. Hutter Construction already has a extensively detailed safety plan that can be seen on their website at the following address: <http://www.hutterconstruction.com/Safety.asp>.

After being able to meet with the various industry professionals, I've found that there would be one great contact to help advise me in this topic as well as my thesis depth analyses. This industry professional would be Bill Moyer of James G. Davis Construction. I feel that Bill Moyer would be a good candidate as he has experienced tragic occupational hazards first hand. This type of incident gives him the experience and understanding of how to see the potential hazards that exist on the site, and how to mitigate issues that happen after damages are incurred.

Breakout Session 2: Multi-trade Prefabrication and Modularization

During this session, industry professionals such as Dr. John Messner, Bill Moyer, Ray Sowers and Patrick Harrison all discussed ideas for how to properly devise plans for prefabrication and modularization. Aside from the plans used to implement prefab design, we also discussed the various types of structures that most commonly utilize prefabrication systems. These structures include precast parking garages, healthcare facilities (headwalls), pedestrian bridges etc.

I found it quite interesting that so many types of structures utilize prefabrication and modularization, and these methods can drastically decrease the duration of a projects schedule. Due to this fact, I will attempt to utilize prefabricated systems in my thesis depth analysis as they may drastically decrease my projects schedule, which would be beneficial to Atrium as they would be allowed to inhabit the facility sooner. There are a lot of concerns when dealing with precast systems that will need to be taken into consideration when doing my analysis. These concerns include but are not limited to; crane/hoisting, trucking/transfer, staging area, permits, labor, transit route etc. All of these things must have great care appended towards them in order to ensure a successful system installation. If these priorities are not met, the schedule duration may not be increased in the manner intended, which defeats the purpose of a prefabricated system.

They key contacts that I believe would be able to accurately assist and advise me in my thesis ventures would be Patrick Harrison of Systra and Dr. John Messner of the AE Department. Both of these individuals seem to have a great deal of experience as well as expertise in prefabrication and modularization.

[Feedback from Industry Roundtable]

After our breakout sessions concluded for the day, my fellow classmates and I were to separate into small groups of 2-3 individuals and sit down with an professional in the construction industry. I ended up joining a group with Josue Fernandez and Brad Williams. Our industry professional was Jason Reese from Balfour Beatty Construction. During this time we each took a few minutes to describe specific aspects of our thesis buildings to our industry professional, that way he could provide us with ideas and strategies for developing a concrete analysis for our thesis proposals.

The features described to Mr. Reese, about my building, were that it is a one story, medical equipment manufacturing facility that caters to a variety of building uses such as; manufacturing, warehouses, research and development, engineering shops, storage and offices. I also described that the building rests on a 101,200 SF footprint and is constructed with cast in place foundations as well as slab on grade and a steel super structure. The project schedule for this building's construction lasts just over one year and is intended for completion in June of 2014.

After describing the details of my building, with the minimal time allotted, Mr. Reese had provided me with two simple approaches to develop a depth analysis for spring semester. The first topic for analysis would be to drastically increase the project schedule. This is generally a desire on most projects, such as; can we get the project completed before the scheduled completion date? Mr. Reese felt that if I could research ways to fast track my project, that I would have a possibility for analysis there. He suggested that I look into prefabrication and modularization of major building components, to help minimize installation time by an alarming amount. For this analysis, Mr. Reese suggested that I investigate information on this topic by contacting and consulting a prefabrication specialist. He also proposed that I possibly develop a SIPS schedule to help define and constrict construction activities to a specific deadline. By doing this, decreasing the projects duration may be more feasible when combined with prefabrication methods.

The second topic for analysis would be to research ways to lower the project cost, also a common goal on most projects. He suggested that if I utilize prefabrication methods, that materials alone may cost less than what is currently being implemented. If I wanted to accurately analyze the cost effects of prefabrication, I would need to take into consideration all of the variable systems that must be implemented for this method to take place, such as; trucking, crane/hoisting, labor, staging etc.

Overall the feedback from the roundtable breakout sessions, as well as the concluding discussion with the industry professional, was a success. I've been able to gather information on possible areas for analysis which will help me compose my final thesis proposal.

Appendix A: Roundtable Notes/Feedback