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Library in Metropolitan Washington, D.C
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Library in Metropolitan Washington D.C

Technical Assignment 3

Picture Provided by Multivista from Onsite Webcam

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Executive Summary

Setting up phone interviews with the project team for the library has opened up many options and interests of construction concerns. Phone interviews were conducted with the contractor's project manager, the contractor's field engineer, the architect, and the construction manager's project manager.

Early in the project design phase the library was cut from seven floor design down to a five floor design with no residential portion, three floors of library, and two floors of art gallery space. Once the contractor was selected, the critical path items were determined to be excavation, caisson installation, startup submittals, structural steel, floor slabs, curtain walls, IPEC, and GWB walls, and coordination of material deliveries. Delays arose early in construction with a half a month delay due to permitting issues, and a half a month delay due to caisson installation issues. Multiple schedule acceleration scenarios have been noted and have the potential of regaining lost time for the schedule. A few schedule acceleration items are; more coordination in preconstruction for the caisson installation, a less complicated and earlier submittal process, better understanding of how much resources are needed for the complex structural steel, better specification supporting documentation for the curtain wall and it's mock-up, and a more elaborate site logistical and material delivery plan. If the substantial completion date is threatened and is not met by the contractor, the contractor will be responsible for $5,227 per day of their own general condition costs and a $6,940 per day penalty to the owner specified in the specifications.

There were no specific value engineering requirements or pushes incorporated on the library project. In fact, some of the project team mixed up value engineering with cuts in scope, cost, quality, and time. A fairly basic example that may be classified as value engineering that was used on the project was the selection of the escalator and elevator manufacturer. This manufacturer was proposed by the contactor because the contractor trusts them, and the contractor has never managed a job that included an escalator. A true value engineering topic that was chosen by the architect included the selection of the integrated packaged equipment center (IPEC), which has maintenance and life cycle benefits over a traditional mechanical penthouse. On the exterior skin on the library, a substantial portion of the building enclose is curtain wall, in which is UV protective glazing. This minimizes the effects of UV damage to the books, however the implementation and procurement process may have a negative effect on the project. Also, as a way to add more self-preformed work to the project and to oversee quality control in a better way, the contractor proposed to use self-adhering air barrier instead of the specified spray-applied air barrier because the contractor a certified installer of this type of air barrier. One of the last noted value engineering topics was the use of terra cotta panels for some parts of the building's skin. Terra cotta wall panels offer numerous benefits, such as install time savings, cost savings, graffiti protection, and decreased dead weight.

Information about The 22nd Annual PACE Roundtable was included in the last portion of this report. During the first break-out session information management for the workforce was discoursed and in what ways information could be better collaboratively shared on any project. Patrick Harrison, whom is a Vice President of Systra, gave a presentation on what must be considered when coordinating the construction of a new railway and how many tests are required to ensure that all the systems communicate correctly with each other. In the afternoon, the second break-out session was on topics of multi-trade prefabrication, which included what types of projects it can be done on, its' benefits, transportation requirements, and how financial institution may reject the idea of prefabrication.

Project Management Interviews

Schedule Acceleration Scenarios

Design for the building was a lengthy process using a Charrette process, as mentioned in previous reports. At first the design started out as a seven story residential tower that would house the new county library on the lower floors. To accomplish this, a developer would have had to been brought onboard very early in order to make proper arrangements. Because the economy was not performing very well at this time (early 2009), there were not many developers building in the area. After the search for a developer tuned up nothing, the county decided to move along with the project and to cut the residential tower out of the building for the sake of time and getting the design complete to be bid out. With the residential portion of the building removed, the number of floors will be five, which allowed three floors of library and two floors for a nonprofit art group. However, the county was still pressed for time and wanted to get their new library project started, so the county chose to let the first two floors be fit out in the future because if the design waited for the art group to design their space, then the project would be delayed longer.

Critical Path

When the contractor was brought on board, much of the site utility work was already done or well underway. This included installing underground electric, rerouting water, natural gas, sanitary sewer, storm and other required utility services. Most of this work was done early on along with acquiring the property and demolishing the few existing building as to not interrupt the overall main construction phase of the project. Because this was done early on, this scope of work did not affect the critical path of the project. A number of problems did arise while the permitting phase was in progress. As a result the library project was delayed approximately half a month.

Once the notice to proceed was given, the primary critical path items are excavation, caisson installation, startup submittals, structural steel, floor slabs, curtain walls, IPEC, and GWB walls, and coordination of material deliveries. These key items are classified as critical path items because they either have already delayed the project or have the potential to delay the overall completion date if not completed on time. On the other hand, if these activities are completed ahead of schedule, then these activities have the potential to accelerate the schedule and make-up delays that already exist in the schedule.

Excavation for the library was not an issue. There was a small section of lagging and dewatering that was required along the neighboring residential tower of the excavation. More equipment would not help in the excavation productivity because the excavation was somewhat small and extra pieces of equipment would simply get in each other's way. This could actually cause more delays instead of creating schedule acceleration. What really was the limiting factor in the excavation was how quickly a dump trucks could get into the site, get loaded, and then haul the soil to the required location. The access road that allowed the trucks to pull in, get filled, and drive off the site in one continues sweep helped the excavation stay on time, and not cause any issues.

More problems arose with the installation of the caissons than in the excavation. Each caisson had to be field verified to ensure proper bearing capacity was achieved. This was a very lengthy process that required the caissons to be drilled, the bearing capacity verified and signed off on, fabrication of the reinforcing cage, and pouring the concrete. Overall, the total caisson installation delayed the project another half month. Would the design and verification process been planned out better with better coordinated, the time required for each caisson would have dropped, in turn making no significant delays. Costs associated with more time

spent upfront planning the caisson process would be minimal compared to the benefits of savings time and effort while in the field during installation.

All start-up and material/ systems submittals were supposed to be submitted within 120 days of notice to proceed. Because some items were/are harder to procure than others, a notable amount of the submittals are being completed later on in the project as the issues are brought up. This may be creating a small amount of tension between the parties involved on the library project because the submittals take time to process and must have a final approval before the item can be installed. In some cases, alternatives or substitutions are being proposed by the contractor, which differ from the specifications. As such, the architect must review the proposals and make a recommendation to the owner as to whether or not to approve them. The administrative process required for this review can take some time, in which can stall the flow of work if the submittals are turned in soon before the work must be done. It has also been noted that other common documents and approvals have been taking an excessive amount of time to be responded to. Two different scenarios can be followed to accelerate delays caused from this procedure. One, the steps taken to review such submittals and proposals could be restructured as to require fewer parties or individuals to approve the items. Two, the submittals could be submitted earlier to allow the current administrative process time to approve them. The cost of changing how documents are processed, and being sure to get submittals in early may not be high, but have the potential to save a lot of time and money.

A concern about the productivity of the structural steel erection was laid out in a phone interview with the contractor. If there was a case where the schedule absolutely had to be accelerated, then the productivity of the structural steel erection would be on the list of items to accelerate. When first coordinating the structural steel erecting an error was made by the specialty contractor in that they assumed steel erecting would proceed on all parts of the building uniformly through all levels. In coordinating with this trade, this was changed to a more accurate estimate where steel will be erected on the main building and pavilion section from the first floor to the fifth floor, then the trusses will be hung, and the rest of the overhanging section will then be filled in by hanging members from these trusses. On the library project the structural steel specialty contractor has a five person crew. Using RS Means as a reference guide, when erecting structural steel similar to what is being used on the library project, a crew of E-2 should be used. In the crew tables in RS Means (see Appendix A), Crew E-2 refers to one structural steel foreman, two equipment operators, and four structural steel workers. It is important to note that the structural steel for the library project is somewhat complex and should require slightly more workers to ensure a safe and complete process. It may be safe to assume that the structural steel specialty contractor did not fully understand the complexity of the structure used in the library. To increase productivity, another five person crew could be utilized because the 200 ton crawler crane on site is not being utilized 100% of the time and is sitting idle at some instances. Another 200 ton crawler crane dedicated for structural steel could not be utilized logistically on-site, but because the current crane is not at full capacity another crew could be feasible. This is even more so because there is, however, a 120 ton mobile truck crane on site from the contractor that is used generally for other trades, not the structural steel erector, which frees up the 200 ton crane to be solely dedicated to structural steel.

A very critical portion of the schedule involves the curtain wall system. The building dry milestone relies on the completion of the curtain wall and is required for a large number of interior finishes. A manufacturer was proposed for the curtain wall by the contractor to meet the specification. It is important to note that once again the documentation required for the approval of this manufacturer had to be worked out and approved. This process is taking a considerable amount of time because parts of the specification is not being properly

satisfied. The mock-up of the curtain wall that is required by the specification is also in jeopardy and will be discussed in more detail in the Value Engineering Section below.

In coordination of the IPEC unit, it was noted that issues arose while receiving much needed details from the supplier. A more streamline approach is needed to properly coordinate with the supplier. If a different supplier was chosen, the coordination time may be reduced because of how the supplier picks the equipment to be installed in the IPEC verses making the parts and equipment in house. On the other hand, because the IPEC is a very critical peace to the building and designed as a customized unit, if a different supplier was chosen this late in the project, then the designers would have to re-evaluate the design and potentially delay the procurement of the IPEC unit a substantial amount of time. The amount of redesign work and costs associated with the redesign of this unit trumps the extended coordination time frame that is required with the current supplier.

A key aspect on every job site is how the coordination of material deliveries are handled and managed. In the event that a schedule compression is needed on the library project, material deliveries could have been handled differently. Some amount of off-site storage is already being used for the project. With the size of the site being the limiting factor as to what can and can't be stored on site, if more materials were procured earlier, than they would have to be stored off site. This creates more documentation requirements such as delivery confirmations, invoices, warehouse confirmation, warehouse certification, and pictures of the stored materials. As an alternative to this, a more thorough site logistical and material delivery plan would have to be developed. More employees from the contractor could even be brought onto the project to help manage the material deliveries because the current number of employees from the contractor are already being fully utilized. This solution could also be beneficial for the project in other ways as well, such as more time to spend organizing proper documentation for submittals and a crew dedicated to managing the pavilion construction. This can be weighed when considering an acceleration scenario of the pavilion construction. Structural steel will be erected in the pavilion fairly early on in the project, but in the contractor's schedule the pavilion space is then left idle while the rest of the building catches up to the finished structural steel there. If metal decking was laid in the pavilion as soon as the structural steel was installed, then work could proceed in this space and stay ahead of the rest of the building, in turn positively affecting the schedule. With metal decking laid, slab work and layout work would move along in the pavilion space quickly.

Risks to Project Completion Date

Every project has risks associated with the completion date in some form or another. The most common form of these risks is the contractor's General Condition costs, or the cost that are connected with the contractor being mobilized onsite. In Technical Assignment II the general condition costs were calculated to be $5,227 per day. This is the costs per day that the contractor would feel directly for having their equipment and employees on the job for an extended period of time. Included in these cost are such things as; the site fence, the trailer, the project management team, any other workers that are working for the contractor, any equipment the contractor has on site, and other similar costs.

Another common risk to the substantial completion date is Liquidated Damages that must be paid by the contractor to the owner. In Division Zero on page 42 of the Volume I Specifications, the amount that must be paid to the owner from the contractor is $6,940.00 per day of unexcused delay beyond the substantial completion date set forth in the contract. Other damages may also be owned to other parties involved in the project for delays that push out past the substantial completion date.

Value Engineering Topics

When asked directly about value engineering, the project team seemed to not draw a line between value engineering and cutting of scope to directly cut cost, quality, and time. However, there were some add alternatives proposed that where not associated with value engineering, but could be classified as a value engineering items.

Escalator

In every public project that incorporates an escalator in its' design, the quality control and coordination of the escalator can be a constructability concern. A particular concern to the contractor on this project would be that this is the first project they were involved with that utilizes an escalator. Because of this, the contractor simply is not familiar with the typical requirements and coordination issues that may arise during the construction of escalators. On the library project, the escalator and elevator manufacturer is one in the same. However, the contractor has never worked directly with one of the specified manufacturers. Therefore, the contractor proposed an escalator and elevator manufacturer that they were relatively familiar with and that they trusted to work with because of the contractor's absence of experience with escalators. Proper documentation was not obtained to prove to the architect that this manufacture could provide a truly equal system to the one that was specified, so conflicts arose.

Figure 1 (Example of Inside IPEC)
Picture provided by Systecon Inc.

Figure 2 (Example of IPEC with no Shell)
Picture provided by Systecon Inc.

IPEC

A very critical piece of equipment that caused trouble and controversy on the library project was the IPEC unit. An example of two different IPEC units can be seen in Figure 1 and 2 above. The integrated packaged equipment center was debated extensively with numerous case studies and research by the architect. Benefits and weaknesses of both a traditional mechanical penthouse and an IPEC system were laid out early in the design phase. For a comparison of the benefits and weaknesses of each system see Table 1 below. One item that was not a primary driver to the decision to use an IPEC was the construction costs because an IPEC actually costs slightly more or the same as a tradition mechanical penthouse. A key differentiator of the IPEC was the less amount of maintenance and the life cycle costs of the factory assembled components as compared to the field assembled penthouse equipment.

Table 1 (Equipment Housing Comparison)		
Type of System	**Benefits**	**Weaknesses**
Traditional Mechanical Penthouse	Ease of Specifying Hand Select Equipment Permanent Structure/ Housing Common/ Well Known	Coordination of Trades in Confined Space Costs of Building Enclosure Quality Insurance
IPEC	Less Internal Coordination Potential for Longer Life Fully Customizable Integrated Equipment Prefabricated Assembly	Costs of Customization Early Coordination of Tie-ins, Roofing, and Structure Small Number of Manufacturers One Large Critical Lift

An IPEC manufacturer and model was chosen well before bids were opened for contractors. This specific unit was then used as a basis of design to design the rest of the building; such as allowable loads, volume flow requirements, and sizing of secondary systems. After the contractor was chosen and the IPEC was being procured, the contractor noticed the specified manufacturer assembles the components of the IPEC using a variety of other manufactures parts and equipment. An alternative suggested by the contractor proposed a different manufacturer of the whole IPEC to a company that the contractor had again worked with before. This suggested supplier designs and manufactures the parts and equipment they use in their own products. This could have the potential of making the coordination process easier and the reliability of the system higher. However, if the supplier was changed as late as the recommendation was made in the construction process, then the architect would have to do a significant amount of redesign work to accommodate the different system. Because of the highly customized nature of this system, the two different suppliers' products cannot be used interchangeably. As a result, the originally specified and designed IPEC supplier will be used. All-in-all this process of recommending an alternative supplier, has delayed the IPEC and the coordination process that comes with this unit. Coordination that is in progress is problematic and the project team is having a hard time getting documents for the IPEC from the supplier approved.

Curtain Wall

This library's curtain wall is unique in that a library typically has little glazing because books can be easily damaged by UV light. Because of this, windows are typically minimal. However, in this library, a substantial portion of the exterior facade is a curtain wall system (as seen in Figure 3). Overall, when more natural light and views to the outside are provided to a space, it becomes a more pleasant space with a positive environment. This is accomplished by applying a UV protective coating on the curtain wall to minimize the amount of UV rays that can enter the library. This in turn will save the books from getting damages as well as supply a better environment for the library visitors and users.

Figure 3 (Interior Rendering of Library Space)
Rendering provided by The Lukmire Partnership Inc. 2012

Because the curtain wall covers such a large square footage of the building's exterior, it is important to ensure procurement and installation go as smoothly and seamlessly as possible. Had the contractor been brought on

earlier in the project, a curtain wall suppler could have been chosen early, specifications would be more focused on the contractors supplier, and mock-up requirements could have been discussed and well defined. Instead, a supplier was chosen that ensured the contractor a faster fabrication time than other curtain wall suppliers and that could still supply the required system, which was advantageous to the contractor because the schedule is in need of acceleration. It is important to note that value engineering is not just about saving time on the schedule. There have been complications in getting the shop drawings from the chosen supplier approved by the architect. Also, while bidding the project, the contractor may have left out the required offsite mock-up that must be tested for the curtain wall approval. Time is pressing thin to get the shop drawings approved and the mock-up approved so that fabrication of the curtain wall can begin and not hold up other critical path items, such as the building dry milestone. The architect and construction manager on site are not willing to except the risk of allowing the contractor to run the required tests on an in place mock-up portion of the curtain wall because if it fails, major over run costs could come back on the owner directly. The idea of the curtain wall to allow natural light and outside views is a great benefit to the building, however the implementation and procurement has the potential to hurt the project's schedule

Air Barrier

As specified in section 07 2726, the primary air and rain barrier to be used for the library project is a spray-on or flat trowel applied complete and continuous unbroken film of liquid membrane. A self-adhering vapor permeable air barrier membrane is to be used in secondary locations around the building. Early in the submittal stages of the project, the contractor proposed to change the primary air and rain barrier for the building to entirely the self-adhering membrane type. One of the biggest reasons for this proposed change was because the contractor is a certified installer of this type of membrane air barrier. The fact that the contractor can self-perform work, in general, was one of the reasons they were awarded the project as mentioned in Technical Assignment I. If the contractor's employees are the ones installing the air barrier, then the contractor will have more control over the quality assurance that in turn will drive a higher quality product. Also, a self-adhering membrane is less dependent on the current weather. A constructability concern noted by the contractor was the time needed for allowing the spray applied membrane to dry. However, in any case of switching air barriers or water barrier types, the compatibility of the barrier with the specified insulation is a concern, and may require a different insulation type.

In determining if the contractor's request was acceptable, the architect weighed the benefits and the negatives of each type of air barrier, which can be seen in Table 2 below. A typical mock up from a Henry catalog (a specified possible supplier of the air barriers for the library project) is also shown in Appendix B of both the spray applied and the self-adhering membrane air barriers. If the contractor can prove without reasonable doubt that they can offer the self-adhering membrane at equal or better quality than the spray applied membrane, then the architect would accept this alternative. In this case, the architect did decide to allow the contractor to use the self-adhering membrane, in turn allowing them to self-perform that scope of work.

Table 2 (Air Barrier Comparison)		
Type of System	**Benefits**	**Weaknesses**
Spray/ Trowel Applied	Forms a Continuous & Complete Membrane Easy to Apply Around Penetrations (Masonry Anchors)	May Have Extensive Backing Surface Requirements Drying Time Must Accounted For Strict Weather Requirements (Containment)
Self-adhering Membrane	Less Strict Weather Conditions Minimal Drying Time Less Prep to Backing Surface Improved Health of Installer	Lapping of Layers Sealing Around Every Penetration Primer Backed Redesign Required

Terra Cotta Rainscreen Panels

According to the project team, terra cotta panels for exterior finishes are somewhat new and have not been widely used by the architect or contractor in the past. There are two types of exterior finishes used in the library project besides curtain wall, which are terra cotta panels and cast stone masonry unit walls. A typical detail of each can be seen below in Figure 4 and 5.

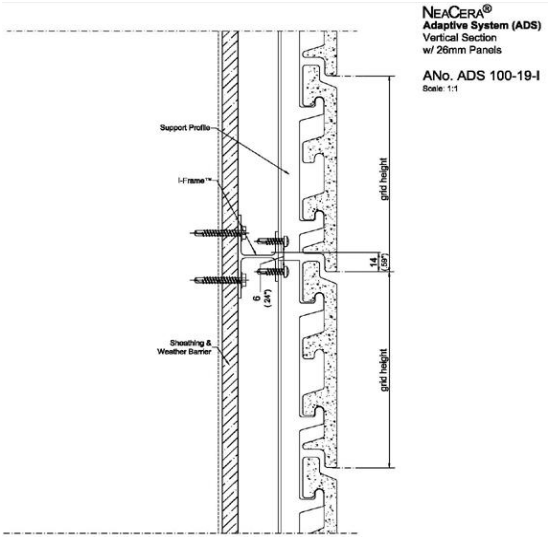


Figure 4 (Terra Cotta Panels Section)
Picture from Avenere Cladding LLC

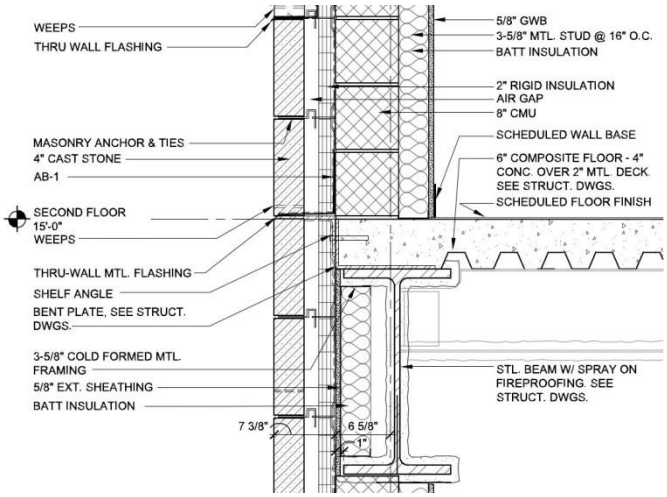


Figure 5 (Cast Stone Section)
Picture from Construction Documents provided by MBP

Terra cotta wall panels could be thought of as a value engineering topic of sorts because of their numerous benefits over traditional veneer brick or cast stone units. A grid of aluminum support railings are fasted horizontally and vertically to the subsurface using simple stainless steel screws. The vertical rails are shaped in such a way to inter lock into the terra cotta panels, as seen in Figure 4. The horizontal rails (I-Frames) act as a support system for the vertical rails by fastening into the subsurface, also seen in Figure 6. Once the aluminum support structure is installed the terra cotta panels are easy to place by a technic that the manufacturer calls "Lift & Lock". No special tools are needed because the panel is literally lifted into place on the top hanger and then the bottom portion of the panel is pushed on, locking it into the structure. This process is faster, easier, and cheaper than laying traditional masonry.

There are other benefits terra cotta panels have over masonry units. As a way to differentiate their product, this supplier offers a graffiti guarantee that guaranties the graffiti will wash off with the proper cleaner. Overall, the terra cotta system is somewhat cheeped than a built up masonry wall. Also, each terra cotta panel weighs between 7 and 15 pounds, which makes them manageable to move/ install while also cutting the load placed on the structure of the building from the dead load of the panels. All of these benefits add together to create an easily cleanable product that can accelerate the schedule and minimize the budget of any project, while not sacrificing quality. However, under some circumstances, terra cotta panels may break easier than masonry units from small momentum impacts. Because of this, it is not recommended to use terra cotta in areas that may be in contact with traffic or pedestrians on a daily basis.

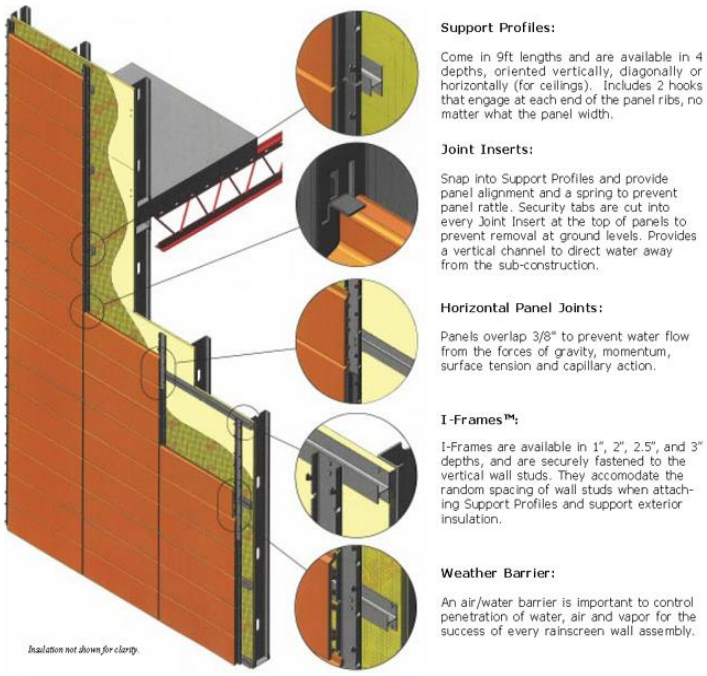


Figure 6 (Terra Cotta Assemble)
Picture from Avenere Cladding LLC

Late Value Engineering Topics

As a side note, some great value engineering topics have been brought up in project meetings. Unfortunately, most of these have been thought about too late in the project to be implemented. If a different project delivery system was used, such as design-build or one that brought the contractor on earlier, then the contractor could have had feedback on writing the specifications. Also, the contractor's input would have been valuable in designing the building while and selecting the IPEC, air barrier, curtain wall, and other essential components of the building. This early collaboration would have greatly benefited the project team members' relationship and the overall quality of the construction process.

PACE Roundtable

In Appendix B the Student Break-out session note sheet and the Industry Member key feedback and suggested resources note sheet from The 22nd Annual PACE Roundtable was included.

As a crucial and beneficial way for industry members to interact with the Construction option students the PACE Roundtable is hosted each year here at Penn State. This year's PACE Roundtable was held on November 7th, 2013 at the Penn Stater Hotel and Convention Center.

Critical Industry Issues

Break-out Session 1-B (Information Management for the Workforce)

In this breakout session the discussions mainly focused on critical flaws in the way information and communication is handled in the industry on an everyday basis. To start off the discussions, the idea of a way to spend less time annotating and more time designing would greatly benefit the design community. This is

related to the amount of time a designer must spend on dimensioning and labeling drawings to create a drawing set. If a designing tool in some way could make this process easier and shorter, then in turn, the designer would have more time and resources to allocate to bettering the design as a whole. With more thought incorporated into the overall design of a project, there would be more room for integration and more collaboration between designers and construction managers.

Another big issue in the industry related to information exchange is the lake of communication that the different forms of software have. Over the years, the amount of technology has exponentially increased. This has pushed the use of modeling software into the construction industry. The types of modeling software have evolved in an organic way. That is, the software from a variety of different sources has been specialized in a very splintered manner to an extent that there are hundreds of different types of software and very little of them communicate with each other. This has happen because each contractor and some owners have had needs for a specific uses of the software and have customized their own version to meet these needs. Recently there has been a push to bring all these separate entities together and create just a few different options of software instead of hundreds. In short, a great way to do this is by larger vendors buying out smaller venders, and then incorporating the tools of both into one entity. One such example is what Autodesk has been doing for the past few years. This is happening more and more which will benefit the industry in a variety of different ways. One such benefit will be in not having to redraw items that were drawn in one such customized software because redrawing an item wastes time, money, and resources.

Going off of the topic of eliminated redrawing of elements, the topic of creating standards of who should model what was introduced. It is important to know at what point the designer should stop designing/ modeling and the specialty contractor should start designing/ modeling. The specialty contractor knows the best way to do the final small details of how a system is put together or installed. This is why the specialty contractor should design the final details of a system. This would cause less redrawing work, as mentioned above, and higher efficacy of the specialty contractor. The idea of using software that is compatible also plays a role here in order for the information and model to be pasted from the designer to the specialty contractors.

It was brought to the attention of the group that some members of the project team, particularly the older more veteran ones, are resisting the implementation of new technology. A cause of this may simply be because the technology is intimidating to them and they don't know how to use it. Many of the veteran superintendents are so use to holding a piece of paper in their hands that switching to a table portal seems impossible. These concerns and resistances typically will diminish when the users learns how to use the new technology. To improve the learning curve, leaning sessions can be set up and college grads can be educated to be a mentor for pushing the new technology. College grads can teach the veteran project team new technology while the project team can teach the college grads about the industry and how things should be done.

As a closing industry concern, who has rights to "The Model" and how can the model be used, was discussed. Contractually, who is responsible for the model? This party is not going to want the liability of other parties having editable access to the model. However, there is a need for most of the parties to have access to the model for full collaboration and to easily make changes. Also, a question came up, "Would it be beneficial to limit the amount of drawings required in a set of documents, if the model was very detailed and accurate?" To answer these questions and concerns, it was recommended that a Field Information Manager be used. This project team member would manage the model, developed information from the model, edit

the model, select and share with the team what the model would be used for, and how accurate or reliable the model would be.

After discussing these topics for quite some time, a number of suggested thesis topics were proposed to give undergrads and grad students ideas for their thesis projects. A few such topics could be;

- What is the true cost impact on our thesis building of redesign work done by specialty contractor?
- How does the delivery approach of a project influence the information exchange?
- How could the savings of bringing on contractors and specialty contractors early be quantified as compared to a competitive bid?
- Where did the project team draw the line between where the designers stop designing and the specialty contractor picks up the design, on the students' thesis project?
- Who is responsible for the model, how accurate is the model, and what is the model being used for?
- What is the owner's role in the information exchange process?

Patrick Harrison (Guest Speaker)

Patrick Harrison is a Vice President of Systra based out of New York City, New York. He has worked more than 36 years in system coordination, engineering, construction, and start-up for railway complexes. It is important to understand that, in these systems all of the subsystems must function as one integrated system when completed. The process to inspect and test all the subsystems that go into creating a railway take a long time and can be very tedious. These systems must communicate effectively with each other even though they are from a variety of different manufacturers, and some manufacturers products are known to not be compatible with one another. The key for a successful project is constant coordination from the very start of the project and ensuring that all the contractors have as much information about the project as possible to bid on the project.

Break-out Session 2-C (Multi-trade Prefabrication)

Beak-out session 2-C primarily discussed ways and considerations of multi-trade prefabrication. Limiting factors of prefabrication were discussed first. There are typical markets were prefabrication is commonly used, which include MEP rough-in for healthcare sectors, precast parking garages, pedestrian bridge, architectural finished, and MEP in other buildings that are heavy on MEP rough-in and coordination. Some other uses of prefabrication was mentioned during the discussion, such as duct racks, wet walls, pipe and duct chases, prefabricated mechanical penthouses, and volumetric modularization in building apartments and similar cases. A critical item to consider is which type of project delivery system is being used on the project. A Design-Build delivery system lends itself to implement prefabrication easier. This is because the prefabricated system must be designed to be prefabricated. Another words, it is much easier and less of a coordination nightmare to design a system to be prefabricated, rather than deciding to prefabricate something after it has already been designed. In order for something to be worth prefabricating, it has to be repetitive as well. This means that it may cost more to prefabricate something where the prefabricator is required to customize each piece. An example of this is prefabricated bathroom pods. All the pods should be as similar as possible so they are easier to prefabricate and cost effective.

Because multi-trade prefabrication may involve a unit being at multiple different locations during the prefabrication process, some of these systems can become long lead items. A concern that is typically looked over in this process is who has ownership of the material during the shipping process if there were an

accident or theft? Also, because they are being shipped, the maximum size the prefabricated pieces can be is limited to the permitting restriction in that area.

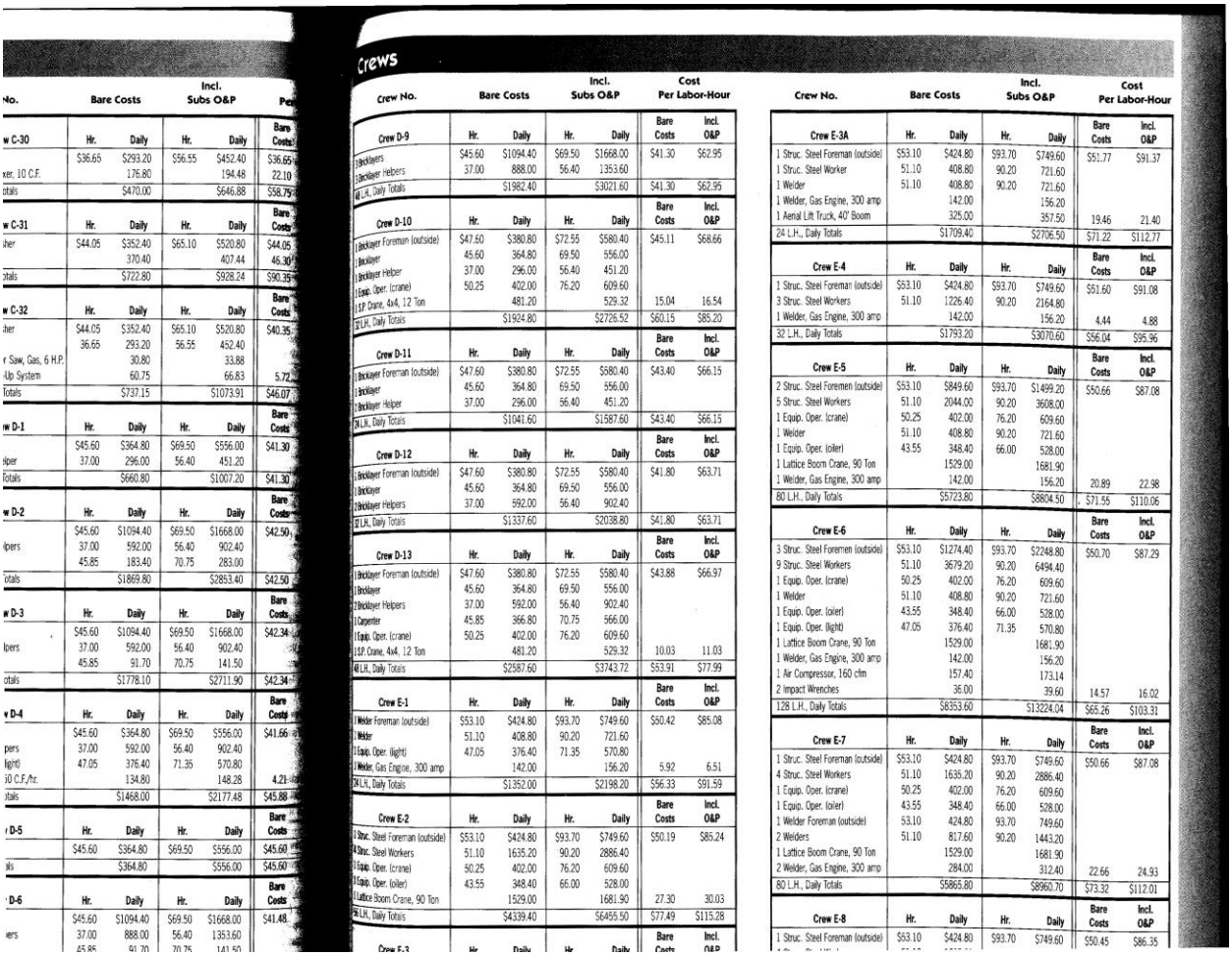
In some cases it has been reported that prefabrication was a challenge to implement because the finical institution in which was financing the project did not want to per-pay for materials that were not on site yet. This may require a lot of documentation to prove to the bank that these pieces of prefabricated systems do exist and are being manufactured. If the bank still is not persuaded, this could stop the prefabrication process altogether. This plays hand and hand in the inspections that are also required by local authorities or special certifications that must be obtained.

All-in-all, multi-trade prefabrication is not done as common as single-trade prefabrication. However, in renovation projects, it is very hard to do any prefabrication because the building itself may not be plumb, and there will be many upfront unknowns. If prefabrication is possible in renovation projects, it will result in schedule savings, which will equate to the building getting turned over faster to be reopened. In order for prefabrication to work and it be the most beneficial as possible, all the trades involved in that system need to buy-in as well as the owner and contractor.

Feedback from Industry Roundtable

See Note Sheets in Appendix C.

Appendix A- RS Means Crew Table



Crews

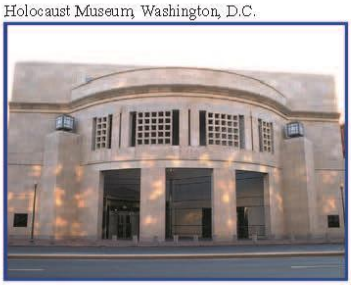
Crew No.	Bare Costs		Incl. Subs O&P		Cost Per Labor-Hour	
Crew D-9	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Bricklayers	$45.60	$1094.40	$69.50	$1668.00	$41.30	$62.95
1 Bricklayer Helpers	37.00	888.00	56.40	1353.60		
48 L.H., Daily Totals		$1982.40		$3021.60	$41.30	$62.95
Crew D-10	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Bricklayer Foreman (outside)	$47.60	$380.80	$72.55	$580.40	$45.11	$68.66
1 Bricklayer	45.60	364.80	69.50	556.00		
1 Bricklayer Helper	37.00	296.00	56.40	451.20		
1 Equip. Oper. (crane)	50.25	402.00	76.20	609.60		
1 S.P. Crane, 4x4, 12 Ton		481.20		529.32	15.04	16.54
24 L.H., Daily Totals		$1924.80		$2726.52	$60.15	$85.20
Crew D-11	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Bricklayer Foreman (outside)	$47.60	$380.80	$72.55	$580.40	$43.40	$66.15
1 Bricklayer	45.60	364.80	69.50	556.00		
1 Bricklayer Helper	37.00	296.00	56.40	451.20		
24 L.H., Daily Totals		$1041.60		$1587.60	$43.40	$66.15
Crew D-12	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Bricklayer Foreman (outside)	$47.60	$380.80	$72.55	$580.40	$41.80	$63.71
1 Bricklayer	45.60	364.80	69.50	556.00		
2 Bricklayer Helpers	37.00	592.00	56.40	902.40		
32 L.H., Daily Totals		$1337.60		$2038.80	$41.80	$63.71
Crew D-13	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Bricklayer Foreman (outside)	$47.60	$380.80	$72.55	$580.40	$43.88	$66.97
1 Bricklayer	45.60	364.80	69.50	556.00		
2 Bricklayer Helpers	37.00	592.00	56.40	902.40		
1 Carpenter	45.85	366.80	70.75	566.00		
1 Equip. Oper. (crane)	50.25	402.00	76.20	609.60		
1 S.P. Crane, 4x4, 12 Ton		481.20		529.32	10.03	11.03
48 L.H., Daily Totals		$2587.60		$3743.72	$53.91	$77.99
Crew E-1	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Welder Foreman (outside)	$53.10	$424.80	$93.70	$749.60	$50.42	$85.08
1 Welder	51.10	408.80	90.20	721.60		
1 Equip. Oper. (light)	47.05	376.40	71.35	570.80		
1 Welder, Gas Engine, 300 amp		142.00		156.20	5.92	6.51
24 L.H., Daily Totals		$1352.00		$2198.20	$56.33	$91.59
Crew E-2	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Struc. Steel Foreman (outside)	$53.10	$424.80	$93.70	$749.60	$50.19	$85.24
4 Struc. Steel Workers	51.10	1635.20	90.20	2886.40		
1 Equip. Oper. (crane)	50.25	402.00	76.20	609.60		
1 Equip. Oper. (oiler)	43.55	348.40	66.00	528.00		
1 Lattice Boom Crane, 90 Ton		1529.00		1681.90	27.30	30.03
96 L.H., Daily Totals		$4339.40		$6455.50	$77.49	$115.28
Crew E-3	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P

Crew No.	Bare Costs		Incl. Subs O&P		Cost Per Labor-Hour	
Crew E-3A	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Struc. Steel Foreman (outside)	$53.10	$424.80	$93.70	$749.60	$51.77	$91.37
1 Struc. Steel Worker	51.10	408.80	90.20	721.60		
1 Welder	51.10	408.80	90.20	721.60		
1 Welder, Gas Engine, 300 amp		142.00		156.20		
1 Aerial Lift Truck, 40' Boom		325.00		357.50	19.46	21.40
24 L.H., Daily Totals		$1709.40		$2706.50	$71.22	$112.77
Crew E-4	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Struc. Steel Foreman (outside)	$53.10	$424.80	$93.70	$749.60	$51.60	$91.08
3 Struc. Steel Workers	51.10	1226.40	90.20	2164.80		
1 Welder, Gas Engine, 300 amp		142.00		156.20	4.44	4.88
32 L.H., Daily Totals		$1793.20		$3070.60	$56.04	$95.96
Crew E-5	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
2 Struc. Steel Foremen (outside)	$53.10	$849.60	$93.70	$1499.20	$50.66	$87.08
5 Struc. Steel Workers	51.10	2044.00	90.20	3608.00		
1 Equip. Oper. (crane)	50.25	402.00	76.20	609.60		
1 Welder	51.10	408.80	90.20	721.60		
1 Equip. Oper. (oiler)	43.55	348.40	66.00	528.00		
1 Lattice Boom Crane, 90 Ton		1529.00		1681.90		
1 Welder, Gas Engine, 300 amp		142.00		156.20	20.89	22.98
80 L.H., Daily Totals		$5723.80		$8804.50	$71.55	$110.06
Crew E-6	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
3 Struc. Steel Foremen (outside)	$53.10	$1274.40	$93.70	$2248.80	$50.70	$87.29
9 Struc. Steel Workers	51.10	3679.20	90.20	6494.40		
1 Equip. Oper. (crane)	50.25	402.00	76.20	609.60		
1 Welder	51.10	408.80	90.20	721.60		
1 Equip. Oper. (oiler)	43.55	348.40	66.00	528.00		
1 Equip. Oper. (light)	47.05	376.40	71.35	570.80		
1 Lattice Boom Crane, 90 Ton		1529.00		1681.90		
1 Welder, Gas Engine, 300 amp		142.00		156.20		
1 Air Compressor, 160 cfm		157.40		173.14		
2 Impact Wrenches		36.00		39.60	14.57	16.02
128 L.H., Daily Totals		$8353.60		$13224.04	$65.26	$103.31
Crew E-7	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Struc. Steel Foreman (outside)	$53.10	$424.80	$93.70	$749.60	$50.66	$87.08
4 Struc. Steel Workers	51.10	1635.20	90.20	2886.40		
1 Equip. Oper. (crane)	50.25	402.00	76.20	609.60		
1 Equip. Oper. (oiler)	43.55	348.40	66.00	528.00		
1 Welder Foreman (outside)	53.10	424.80	93.70	749.60		
2 Welders	51.10	817.60	90.20	1443.20		
1 Lattice Boom Crane, 90 Ton		1529.00		1681.90		
2 Welder, Gas Engine, 300 amp		284.00		312.40	22.66	24.93
80 L.H., Daily Totals		$5865.80		$8960.70	$73.32	$112.01
Crew E-8	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Struc. Steel Foreman (outside)	$53.10	$424.80	$93.70	$749.60	$50.45	$86.35

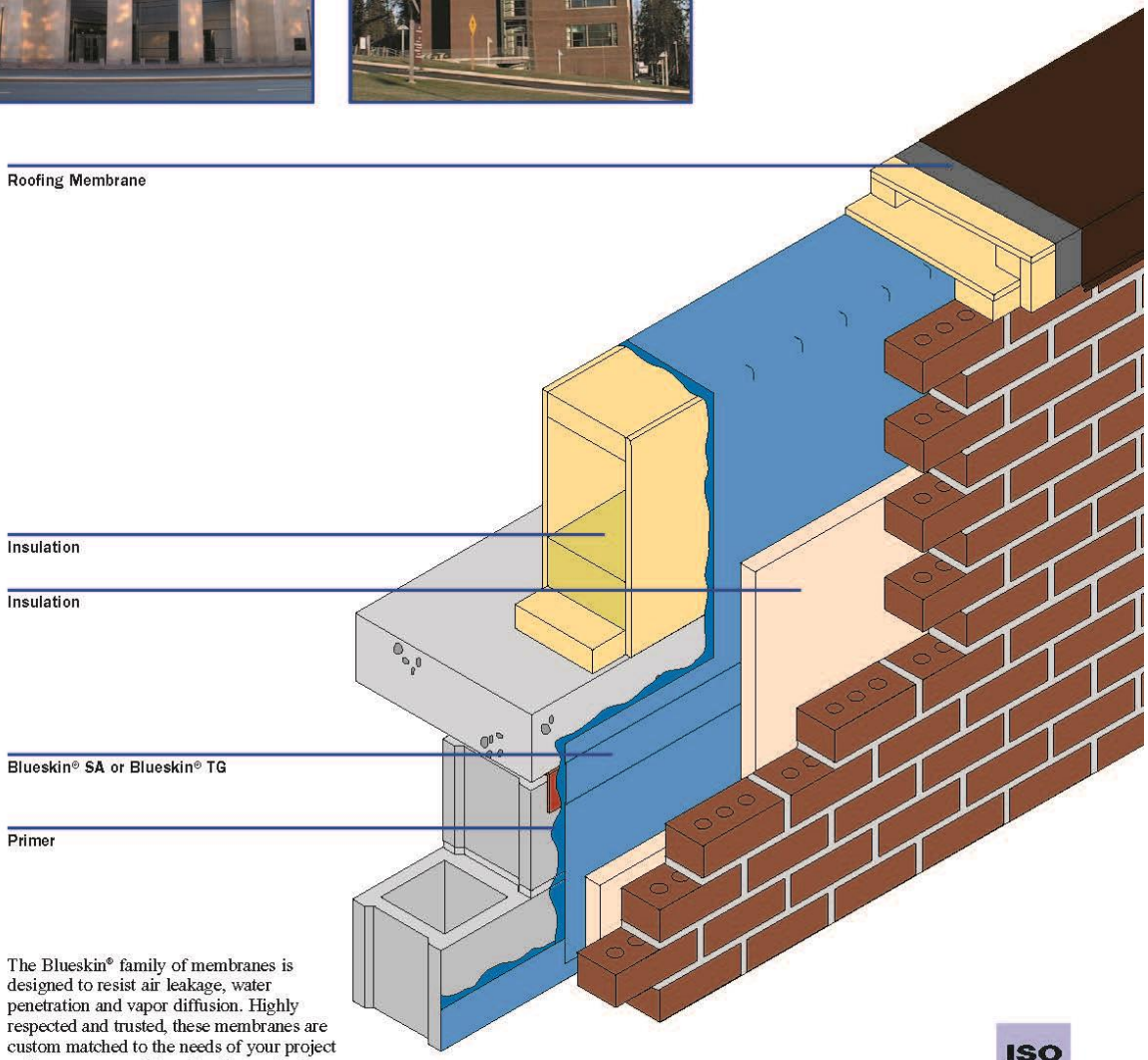
Appendix B- Air Barrier Catalog Sheets

sheet applied
air and vapor barriers

Holocaust Museum, Washington, D.C.



University of Washington, Bothell, WA



The Blueskin® family of membranes is designed to resist air leakage, water penetration and vapor diffusion. Highly respected and trusted, these membranes are custom matched to the needs of your project and can accommodate virtually any design.

Let the professionals at Henry show you!

ISO 9002

Qualifies for LEED Credits

air barrier

liquid applied
air and vapor barriers for cold climates

Federal Courthouse, Boston, MA

Korean Mission to the UN, New York, NY

ISO 9002

Air-Bloc 06, Air-Bloc 21 and Air-Bloc 32 are elastomeric air and vapor barrier systems that remain resistant to rain water penetration. Unlike a dampproofing product, Air-Bloc 06 Air-Bloc 21 and Air-Bloc 32 are self-sealing and will remain flexible. Air-Bloc 32 is a low VOC system.

A Blueskin® transition sheet is used at the interface of dissimilar substrates to complete the system.

Qualifies for LEED Credits

air barrier

Appendix C- PACE Roundtable Feedback from Industry Note Sheets

The 22nd Annual PACE Roundtable

Student Name: Lowell Stine

Session 1: Topic: Rail Projects Integration

Research Ideas:

1) Integration of train station into building → What legal Aspects must be considered?

2) Look at case studies as to how rail station installation has affected local businesses.

Session 2: Topic: Multi-trade Prefabrication

Research Ideas:

1) In public projects the owner has to approve all pre-fab?

2) Which project types and which project delivery types work well with prefabrication.

- Prefabricated mechanical penthouses (Integrated Packaged Equipment center) require a very strict specification.

Session 3: Topic: Information Management for the Workforce

Research Ideas:

1) Feedback from owner may happen too late in project because this is when the owner fully understands the project

2) Many different versions of software exist that are not compatible because companies want to customize their software.

- Where should the Engineer stop designing and where should the sub contractor pick up and finish design to the end?
- Who should have ownership of model, liability of as-built, and permission to edit it?
- With training does the resistance felt to use technology go away? What up front costs are associated with this?

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The 22nd Annual PACE Roundtable

Industry Member: Patrick Harrison of Systra

Key Feedback: *Which research topic is most relevant to industry? What is the scope of the topic?*

Multi-trade Prefabrication

1) Considering project markets
2) Considering project delivery types
3) Requirements for public/private use
4) How to write specifications for prefabrication
5) Integrated Packaged Equipment Center (IPEC) requirements and selection criteria.

Suggested Resources: *What industry contacts are needed? Is the information available?*

1) Patrick Harrison from Systra - has experience dealing with prefabricated railroad substations.
2) Southland Industries - uses prefabrication techniques alot
3) Systecon Inc. - manufactures the IPEC system used in my thesis project.
4) Look at case studies - one example is Chicago's Pacific Garden Mission project used an IPEC unit by Mammoth Inc. a CES Group company.

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Lowell Stine
CM
Dr. Leicht
Library in Metropolitan Washington, D.C
12/4/2013

Library in Metropolitan Washington D.C

Summary of Options

Picture Provided by Multivista from Onsite Webcam

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Problematic Features

Because the library is still in the superstructure phase of construction, it was challenging to guess what areas may be problematic in the future. Some options were discussed with the project team and resulted in the following concerns.

Some issues that are occurring across multiple different trades have the potential to being eliminated, if a different project delivery system was implemented. Currently the project delivery system is design-bid-build. With earlier involvement with subcontractors and vendors the project could have been designed using multiply design-build packages. A few of these packages could be structural steel, curtain wall, and mechanical because these are unique portions of the building's character. Overall, a design-build approach would have been beneficial to this project because the contractor would also be involved early in the design phase.

An interesting issue that was brought up by the contractor was that the structural engineer was not going to allow anything to be hung from the composite slab in the building. This is a concern because the contractor would have to supply additional structural support to hang pipes, ducts, and other utilities in the ceiling. After numerous meeting and coordination with the structural engineer, a set of allowable conditions were established that allowed some objects to be hung from the composite slab. Requirements such as single pipelines smaller than 6", single point loads of 300 pounds, and no equipment with a total weight of over 600 pounds where established. Because of this resolution, an analysis involving this topic may not be beneficial.

Overall, the superstructure of the library is delayed. One thought was to use prefabricated stair and elevator towers instead of the current cast-in-place design. This would accelerate the schedule during the tower's installation and could have potential to make up the current delay. However, the stair and elevator towers are being used as the building's lateral support system in the current design. To make a pre-cast tower system work properly a different lateral support system would have to be used in the design. As a Construction Option student it would be outside my skill level to design a new lateral structural system for this building.

An alternative to the pre-cast towers solution to the delayed schedule could have been an alternative structural steel erection sequence. The structural system of this building is somewhat complex was may not have been fully understood when the project was being bid. A 19 step sequence was proposed by the contractor when the project was bid. An easier or more accelerated way of erecting the complicated structure me exist and an analysis could be done to find a different way to erect the structure.

An architectural interesting element of the building is the 50 feet cantilever in the north corner of the building (as seen in Figure 1 below). While this cantilever does provide the "WOW" factor to the architecture of the building, it is believed that adding a few structural supports under that portion of the building (eliminating the cantilever) would save an enormous amount of resources and money. An analysis could be done to estimate exactly what would be saved if the cantilever was instead turned into a span 50 feet.

As part of the current design an Integrated Packaged Equipment Center (IPEC) unit is being used to house all the mechanical equipment for the building. It would be interested to see how the cost and schedule impacts of this system compare to a traditional site build penthouse. Even the ease of picking an equal product from a supplier would be different from an IPEC to a traditional penthouse. Also, how this choice ties into the project delivery system would have to be analyzed. This could also be used as a breath topic because it would require structural and mechanical analysis and redesigns.

Figure 1 North East Side of Library
Picture Provided by The Lukmire Partnership, Inc.

There have been issues getting shop drawings approved for the curtain wall on this project as well. Because approximately 53% of the building's exterior skin is a curtain wall glazing, it is very important for the sake of the substantial completion date that the curtain wall installation not be delayed. An analysis may be done on potentially redesign the curtain or respecting it so that it is less complicated and can easily be approved. Or the other alternative would be to include the curtain wall as one of the design-build packages so that there are less issues with it's approval. Overall, the procurement of the curtain wall could be improved.

Leading Options

Of the above options four were chosen to be topics of study in the spring semester. These four options are a design-build project delivery system, structural sequence, redesign of the curtain wall, and evaluating the IPEC. Below these topics are discussed in farther detail with thought as to how these analysis could be executed.

In the design-build analysis there will be multiple selections and topics. Currently certain trades of work are having issues getting approved and have the potential of causing delays in the project. Some work is even being done without proper submittal approval. The goal of this analysis would be to eliminate this administrative structure and use an approach that includes multiple design-build packages. Design-build packages have the potential of saving time on a schedule, minimizing coordination issues, and saving relationships of the parties involved on the project. Research can be done by contacting leading industry members that use design-build project delivery systems on a day-to-day basis. How information is currently flowing on the project must be analyzed and how this information flow would change in a design-build scenario. Key data produced by this study would specify a recommended time frame for procuring the contractor, design-builders of the

different systems, and the construction manager. Also, consideration must be given to how this would change the way the specifications are written and how the design-builders are awarded contracts. It is important to note that in this project delivery method the risks associated with errors and omission lie with the contractor or design-build firms. Another consideration that will be incorporated into this analysis is an estimate of how experienced the owner is in design-build projects. This topic will tie nicely into the other three topics that were selected as leading options.

A key construction concern on this project from the very beginning of the bidding phase was the structural steel erection sequence. It was noted by the project team that the man power allocated for erecting the structure is somewhat low, which is not helping the overall structural construction progress. In this analysis different methods of structural steel erection and resources will be considered for schedule and cost considerations. Because of the complexity of the structure, it may also be beneficial to use some type of early involvement in the design from the structural contractor. There are numerous structural faculty members that could have valuable input to this analysis and offer a better understanding of why the structure is designed like it is. There is a potential for a structural breath in this analysis due to the calculations that may need to be performed to ensure the structure can be built using a different technique or redesign parts of the structure so that it can be built. Experience gained in AE 308 and AE 401 will greatly assist in understanding how this structure is put together and potential solutions to be considered.

A unique part of the mechanical system for this project is the IPEC unit. I took an interest in this system and its cost and schedule benefits over a traditional equipment penthouse. In this analysis a penthouse would be design and detailed cost estimates, quotes, and scheduling would be performed. Issues arose in procuring the IPEC for this project so this analysis could also provide information about requirements and delivery options of using an IPEC and a traditional equipment penthouse, which ties back into the first option mentioned above. An IPEC system may be a beneficial system, but it may be easier to implement in a design-build MEP contract. Resources needed to complete a comparison could be produced from the IPEC supplier, the MEP designers, and faculty members in the mechanical option. Possible breath topics include mechanical because of the need to redesign some of the equipment requirements and structural because a penthouse may have a different loading pattern than an IPEC unit.

As the last option for an analysis for the spring semester a redesign of the curtain wall seems to be a feasible option. Approval of shop drawings may create delays in the schedule because the supplier must meet the prescriptive specifications. If the curtain wall system is redesigned and respecified to make it easier to achieve, then the overall construction of the curtain wall will be less impacted by the approval process. A design-build package may also be beneficial for the curtain wall system on this project because the curtain wall covers 53% of the building's envelope. There are factuality members that specialize in building envelopes that would be of great assistance while performing this analysis. Building envelope and structural are possible breath topics for this analysis.

Library In Metropolitan Washington D.C.

By: Lowell Stine
Dr. Leicht
12/4/13

Proposal Options

Proposal Options

Project Introduction

- 95,000 GSF Mixed Use Library and Art Gallery
- Located in Metropolitan Washington, D.C.
- 5 Stories
- Total Cost of $65,000,000
- Construction- Jan. 2013 to Oct. 2014
- County Owner
- Future Light Rail Stop
- 50’ Cantilever

Proposal Options

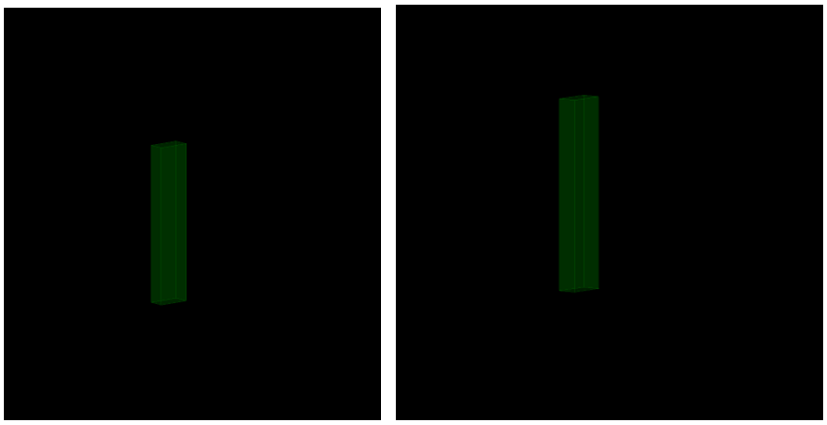
Design-Build Option

- Currently Design-Bid-Build
- Multiple Design-Build Packages
- Requirements of Design-Build
- Recommended Times to Bring Parties Onboard
- Research From Leading Industry Members

Proposal Options

Structural Erection Sequence

- Redesign of 19 Step Structural Steel Sequence Causing Delays (Possible Structural Breath)



Proposal Options

Curtain Wall

- Over 50% Curtain Wall Enclosure
- Lack of Approved Shop Drawings
- Curtain Wall Redesign
- Building Enclosure and Structural Breath

Proposal Options

IPEC

- IPEC Having Procurement Issues
- Compare to Traditional Penthouse
- Detailed Cost, Schedule, and Design Comparison
- Mechanical and Structural Breath