THESIS PROPOSAL

C-5 Fuel Cell Facility

167th Airlift Wing

Martinsburg, WV

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Construction Management

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EXECUTIVE SUMMARY

The following proposal is meant to be an outline of the research and analyses that will be performed during the upcoming semester in the spring of 2010 in order to complete the AE Senior Thesis assignment. Included in this document are descriptions of four areas of analysis, a weight matrix which explains the proportions of time that are expected to be spent on each of the analyses, a section on the breadth topics that will be studied outside of construction management, and a schedule depicting the usage of time for completion of the assignment next semester.

The first analysis that is proposed is the installation of a solar collection system to the roof of the C-5 Fuel Cell Facility. This system will be researched in order to determine the electrical output that could be expected from such an addition and then compared to the expected total power usage of the building. The second analysis involves changing all CMU walls on the project to precast concrete or possibly prefabricated CMU walls. The exterior façade will be examined primarily on the basis of a quality finished product and the interior load-bearing walls will be analyzed based on structural design. In both instances, cost and schedule impacts will be researched, as well as site congestion. The third area of analysis focuses on the creation of an alternative method for constructing the slab on grade in the hangar area. A better final product and simpler construction methods are the goals. The fourth analysis explores the affect that using the design-build delivery method has on project productivity, specifically on the management and design side of the project. Each of these analyses will be directed at studying productivity on a construction project with respect to alternative methods and design options.

The breadth topics that will be discussed in this document focus on the electrical and structural options of Architectural Engineering. The breadth in electrical will come from the analysis of the solar collection system by calculating the approximate quantity of energy that could be produced and then determining the building's overall power usage. The structural breadth analysis will be part of the study on changing the interior load-bearing CMU walls to a precast concrete system. Design of a concrete wall structure based on the current loads will be completed.

ANALYSIS 1: SOLAR ENERGY COLLECTION

ISSUE

In the Request for Proposal documents for this project, there was a bid option to design the building such that it would be capable of obtaining LEED-NC Silver certification. The bid option was dropped because the bids came in over the budgeted amount for the project. It is my personal feeling that if the U.S. government wishes to promote sustainability to its citizens, it should lead by example, even if it means spending a little extra money. As a government-owned project, dropping the LEED Silver bid option due to monetary reasons is not exactly setting a good example. Even if the option is not selected, sustainable features could still be added to this structure.

POTENTIAL SOLUTION

Due to its shape and usage type, improvements upon the C-5 Fuel Cell Facility's energy efficiency with respect to mechanical systems would be extremely difficult. There is a gigantic space that is closed on one end primarily by a fabric door; this is obviously not going to prevent airflow between the interior and exterior of the building. However, there is also a very large amount of roof area on this building that is open to absorbing a great deal of solar energy. This is ideal for solar collection, a process that would reduce the amount of power that the Fuel Cell Facility would be taking from the grid. It is unlikely that enough power would be produced to completely eliminate the building's reliance on other sources, yet it seems reasonable to believe that the payback period for such an investment is far less than the expected occupancy period.

Specifically, a potential product to be analyzed for usage on this project is one developed by Solyndra, Inc., which was discussed in one of the breakout sessions at the PACE Roundtable discussion. This product differentiates itself from the typical solar panels that many owners are trying to incorporate into their buildings through sheer production. The photovoltaic system created by Solyndra is able to convert a much higher percentage of the sunlight which hits the building's roof into electricity because of the cylindrical shape of its modules.

Picture and information recorded above come from Solyndra, Inc.'s website:

http://www.solyndra.com/Products/Optimized-PV

The addition of the Solyndra product to the C-5 Fuel Cell Facility will also serve as a topic for a breath analysis in the realm of electricity. Although it is currently not possible to make an accurate estimation of the quantity of electricity that could be produced by the Solyndra system, it will be researched and calculated in order to find approximately what percentage of the building's total usage could be supplied. Other areas of research that will be necessary are to find the cost of the system itself and installation costs, as well as estimating the schedule impact that might be observed. Since there will be definite increases to the initial cost of the project simply by purchasing this system, it will be important to study the productivity that can be expected for installation to make sure the schedule will not be delayed which would create even more costs. With the information from these studies, a constructability review will be performed to determine if the installation of this solar collection system is a worthy option.

RESEARCH METHOD

- Study characteristics of Solyndra system- electricity production, installation procedures, cost
- Contact electrical engineer to determine expected total power usage of the building
- Determine productivity levels for installation based on information from Solyndra, Inc.
- Calculate payback period for the system based on energy costs

EXPECTED OUTCOME

One of the expectations for this analysis is that the installation of the Solyndra solar collection system would not greatly impact the overall project schedule due to the fact that it could be done once the roof is completed and other activities are going on elsewhere, meaning that it would not be on the critical path. The only potential issue that I foresee is that vent pipes must be run through the roof, so careful coordination for placement of the solar collection system with regards to these pipes would be necessary. Other expectations for this addition are that the project cost will certainly increase, but that the quantity of electricity produced will allow the payback period to fall well within the expected occupancy period by the 167^{th} Airlift Wing.

ANALYSIS 2: PRECAST CONCRETE WALLS

ISSUE

Due to schedule acceleration techniques that were necessary to make up time, masonry work, which was originally not supposed to begin until steel erection was complete, was taking place during the erection process. This created some site congestion issues and also forced the masons to work more quickly than initially scheduled. On the façade of the building, these conditions, along with adverse weather conditions caused some problems with the quality of the finished product, including broken CMU's and the appearance of efflorescence in many locations around the building. Site congestion was also experienced during the construction of the interior CMU walls since other activities such as MEP rough-in were taking place simultaneously. These are problems that commonly occur with on-site construction, especially when the schedule must be accelerated.

POTENTIAL SOLUTION

The use of precast concrete walls for both the exterior façade and the interior walls would lessen the impact of these conditions. For the exterior façade, one of the most important factors to be considered when looking at the precast wall system is whether it is possible to match the aesthetic features that are present in the design with CMU's. The two existing hangars of almost identical design as the Fuel Cell Facility feature the same CMU façade around the bottom portion of the exterior walls, and it is critical that this design feature be maintained on this building. If it is found that a precast concrete system will not be able to meet the aesthetic requirements, a prefabricated CMU wall system that would be constructed off-site will be analyzed. Based on discussions in various classes, some of the major benefits of using a prefabricated or precast system are the improved quality that can be obtained since the construction is done in a controlled environment, as well the reduction of site congestion since the work is taking place off-site. Another benefit which has been explained in class is the increase in productivity. Under controlled conditions the product can be built much quicker, and then once the product arrives on site it is installed more quickly than if masons had been constructing it on-site. Unfortunately, this method requires transportation time as well so it will be important to determine which has the overall shorter schedule. Impacts on the cost of this alternative system will also be analyzed.

For the interior walls of the Fuel Cell Facility, the aesthetic features are much less of an issue since the walls will either be painted or hidden by ceramic tile. The key analysis of a precast system in this portion of the building will be part of a breadth analysis in structures. I will determine the loads that are transferred to the current load-bearing CMU walls and then perform calculations in order to design a concrete wall capable of handling these loads. Based on the crew sizes that are necessary on site for completing both the CMU system, and the precast wall system, reduced site congestion will be a topic of analysis. Cost impact will again be researched as well as the productivity differences which would affect the overall schedule.

RESEARCH METHOD

- Research aesthetic possibilities for a precast system for exterior façade
- If not possible, research means for a prefabricated system
- Contact precast companies- determine productivity, approximate costs for precast systems
- Calculate/determine load on interior walls
- Determine cost and schedule impact

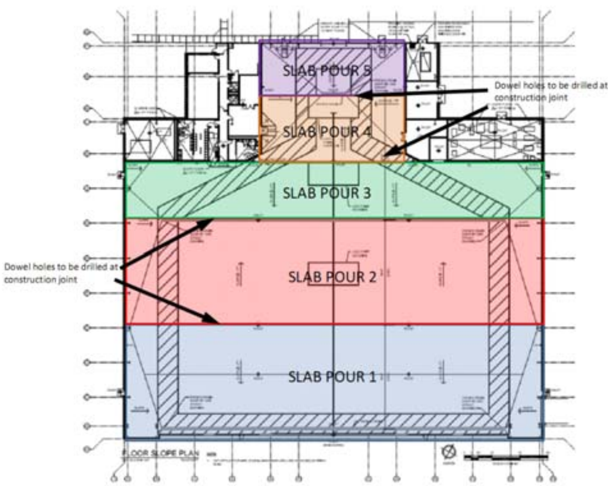
EXPECTED OUTCOME

With regards to changing the façade system, the expectations are that cost will increase, but value will be added through improved quality in the finished product as well as a reduction in site congestion. For the interior walls, specifically those that are load-bearing, the expectation is that the wall thickness necessary for precast concrete will be less than what is necessary for the CMU walls. This would increase floor space within the building. Again, cost will most likely be the negative of this switch since the wall space is not of the magnitude where this system is typically employed. However, the increased floor space and reduced site congestion that is expected will hopefully outweigh the costs. The improved productivity which is expected will also help to offset the cost of changing systems.

ANALYSIS 3: ALTERNATIVE HANGAR SLAB CONSTRUCTION

ISSUE

The hangar slab of the Fuel Cell Facility, as I have been informed by the project team, must meet specific requirements according to the ANG-ETL documents from the Air National Guard, specifically regarding the placement of dowels in the concrete. The document states that all construction joints require epoxy-coated dowels which shall be placed by means of drilling the previously placed concrete. To complete this process in the correct manner, a minimum of 3 days must pass from the time the concrete is placed until the drilling can begin. In order to reduce the number of days that are spent waiting for drilling, the project team decided to complete the slab in as few sections as possible. The diagram below shows the general plan for the different sections of the hangar slab. The bottom two sections are each approximately 75 feet in width.



While this plan for placing the slabs certainly saves some time by eliminating the number of construction joints with dowels, it created many headaches for the project team when it came to determining effective finishing methods. The 75 feet sections are much wider than most slab pours that Kinsley Construction typically deals with on other projects. To complete the process, some of the intended finishing techniques must be modified and potentially compromised.

POTENTIAL SOLUTION

An alternative slab construction plan which reduces the width of the slabs to a more efficient size, while maintaining or reducing the duration of the schedule, will be the goal of this analysis. To determine what exactly an efficient size would be will require research primarily through interviewing multiple people who have done this type of work. I would provide the interviewees with some of the specifications so they can provide informed answers. Some sample questions that I would ask are as follows:

- Do you prefer fewer pours of larger sizes, or a greater number of pours with smaller sizes?
- Which of these options is typically completed more quickly?
- Based on experience, what is the largest width of a pour that can be done while maintaining maximum efficiency?
- How does the width of the pour affect the crew size necessary?
- How does the width of the pour affect the type of equipment necessary?

After I have determined an approximate width for obtaining maximum efficiency, it will then be possible to create an alternative slab pour plan, including a new sequence. The information gathered in the interview stage will then be used to compile approximate costs for the alternative plan. The costs will be based on crew sizes and the different types of equipment that will be necessary for completing the work, which will be estimated according to the interview responses. It will also be crucial to see how efficient an alternative plan could be by using estimated productivities and then finding the new duration for this overall activity. This duration will be compared to that of the method that is being used on the project.

EXPECTED OUTCOME

It is expected that by decreasing the width of the slab pours and creating a new sequence for the placement process, a better overall process will emerge. The value of this alternative solution will be measured based on its schedule impact, cost impact, and proposed quality impact. The expectation is that the schedule will be reduced by increasing productivity for this activity.

ANALYSIS 4: DESIGN-BUILD PRODUCTIVITY

ISSUE

The use of the design-build delivery method for construction has become more common over the years and there have been many advantages found by using this collaborative system. One of these advantages, as discussed in various classes in the AE curriculum, is that productivity in the field is improved due to a reduced number of Requests for Information and Change Orders. Since the contractor and the various engineers are working together in the design stages, fewer questions are left to be answered when it becomes time for the drawings on paper to become a building in the ground. It has been proven time and again that employing a design-build approach decreases the overall schedule of a project, primarily because construction begins before the design stage is complete. A question to be answered is, does this approach create better efficiency for the designers and construction managers?

POTENTIAL SOLUTION

Productivity in the field is fairly simple to measure, whether it is how many cubic yards of concrete were placed in a day, or how many windows were installed in a week. However, quantifying productivity in the office requires further investigation. To analyze this topic, case studies need to be completed comparing similar projects that have been completed with different delivery methods. Fortunately, as mentioned in previous documents for this thesis assignment, there are two hangars on the base of the 167th Airlift Wing which are nearly identical to the Fuel Cell Facility. It is also fortunate that one of these was constructed using a traditional design-bid-build approach and the other was done under a design-build approach. I will be able to gather information from the Contracting Officer concerning the observed productivities of the two projects. It is my hope that I may also obtain contact information for the project teams so I may interview them concerning their perspectives on productivity for each delivery method.

Another area to be researched will be the potential benefits that may not have been fully realized on this construction project. There were some delays in the schedule of this project during the transitions from design to construction, so it will be important to find out what the cause of these delays may have been. Lack of coordination and unfamiliarity with the design-build approach are possible suspects for decreased productivity. Once the cause has been determined, it will be possible to examine the "what could have beens" if the process had gone more smoothly.

EXPECTED OUTCOME

It is expected that the use of the design-build delivery method will prove to yield the highest productivity level for design and management of a construction project. It is also an expectation to find that there are several benefits that could arise from using this approach if all parties are in coordination and are knowledgeable about how the system works.

WEIGHT MATRIX

The weight matrix visually displays the expected distribution of time necessary for completion of the AE Senior Thesis assignment.

Weight Matrix					
Description	**Research**	**Value Eng.**	**Const. Review**	**Sched. Red.**	**Total**
Solar Energy Collection	10	5	10	0	**25**
Precast Concrete Walls	5	15	5	5	**30**
Alternative Slab Construction	0	5	10	10	**25**
Design-Build Productivity	10	0	5	5	**20**
Total	**25**	**25**	**30**	**20**	**100**

CONCLUSIONS

In the construction industry, productivity is one of the major issues that determine which companies will succeed and which companies can fail. The main goal of this senior thesis is to analyze productivity in various stages of the construction process, from the design and management phases to the field work which puts the final product together, as well as the addition of sustainable features to design. The industry is constantly faced with the challenge of building better and faster to meet tighter schedules and lower budgets, so exploration into alternative methods and systems is a must if companies wish to remain in business in today's economy.

APPENDIX A: BREADTH STUDY TOPICS

ELECTRICAL

As part of the solar collection analysis topic, I will be calculating the quantity of electricity that could be produced by the Solyndra system on the Fuel Cell Facility's roof. I will also be determining the total loads for the building in order to calculate the percentage of total usage that the collection system could provide. This will be part of a constructability review of the system for this particular project.

STRUCTURAL

The change from CMU to precast concrete for load-bearing interior walls requires design analysis to determine the size wall necessary for supporting the loads present. I will determine the loading conditions on the CMU wall and size a concrete wall based on those loads. It is my expectation that the precast wall system will have a decreased wall thickness as compared to the CMU wall, meaning that floor space will be increased, adding value to the building.

APPENDIX B: SCHEDULE OF ACTIVITIES FOR COMPLETION

Week	Solar Energy Collection	Precast Concrete Walls	Altern. Slab Const.	Design-Build Prod.
1/11/2010	Research Solyndra characteristics	Research façade possibilities	Create and send survey	Create case study questions
1/18/2010	Research Solyndra characteristics	Load Calculations		Contact Contracting Officer
1/25/2010	Determine total power usage of bldg	Interior wall design	Determine most efficient size to use	Case Study research through contacts
2/1/2010		Interior wall design	Create sequence of pours	Case Study, Research delays
2/8/2010	Estimating- crew, materials, equipment	Estimating- crew, materials, equipment	Estimating- crew, materials, equipment	Case Study, Research delays
2/15/2010	Determine productivity impact	Determine productivity impact	Determine productivity impact	Research potential benefits
2/22/2010	Calculate payback period	Quality enhancement and site congestion analysis	Determine cost impact	Determine potential benefits
3/1/2010	Constructability review	Cost vs. Value review		Determine productivity impact
3/8/2010	SPRING BREAK- Finish last minute analyses			
3/15/2010	WRITE FINAL REPORT			
3/22/2010	REVISIONS AND CORRECTIONS			
3/29/2010	CREATE PRESENTATION			
4/5/2010	FINAL TOUCH-UPS, PRACTICE PRESENTATION			
4/12/2010	PRESENTATIONS			