December 15, 2009

SENIOR THESIS FINAL PROPOSAL

PENN STATE AE SENIOR THESIS

EPRISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ADDITIONS & ALTERATIONS

ALEXANDRIA, VA

PENNSTATE

1855

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CONSTRUCTION MANAGEMENT

DR. CHRIS MAGENT

SENIOR THESIS FINAL PROPOSAL

"Improving Efficiency in the Construction Industry"

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EXECUTIVE SUMMARY

Senior Thesis Final Proposal is intended to discuss the four analyses that will be performed for the final thesis report on the Episcopal High School Centennial Gymnasium Addition/Renovation. Each topic is centered on the central theme of improving efficiency in the construction industry: project procurement efficiency, prefabrication efficiency, energy efficiency and schedule efficiency.

ANALYSIS #1: Critical Industry Issue

The current economy has forced many companies to venture into unfamiliar markets with different procurement strategies. A shift from negotiated GMP contracts to hard bid lump sum contracts requires a change in techniques and methods when pursuing projects. The goal of this analysis is to investigate the influences that shift companies from one market sector to another and assess the changes in strategies and factors of success/failure these companies encounter when pursuing work from the unknown clients and different procurement techniques.

ANALYSIS #2: Elimination of Inefficiency through use of Prefabrication

Site congestion and minimal storage/lay down space has lead to trades working inefficiently and unsafely on site. Currently, the masonry trade is occupying the most space on site and encountering many delays due to inefficient work. The goal of this analysis is to replace the load bearing masonry walls with precast brick panels. A preliminary design of a precast masonry wall system will be performed and impacts to schedule, cost and trade coordination on site will be assessed. This analysis will include a portion of the structural breadth by analyzing and designing additional supports and connections.

ANALYSIS #3: Feasibility and Design Study for Photovoltaic Energy System

The Centennial Gymnasium project is slated to achieve LEED Certification upon completion. However, the project has utilized very few sustainable techniques that could provide a financial benefit to Episcopal High School. The goal of this analysis is to perform a preliminary design of a building integrated PV energy system and determine the financial feasibility to incorporate the system into the existing power plan in order to reduce energy costs for the owner. This analysis will include the second part of the structural breadth by analyzing load requirements and additional structural support for the PV panels. Also, an electrical breadth study will be performed to determine a system tie-in location along with electrical equipment and connection requirements for the renewable energy system.

ANALYSIS #4: Reduction of Overall Schedule through Re-sequencing of Renovation Phases

The renovation work on the project is spread throughout the entire schedule with multiple phased occupancies. Specifically, the Wrestling Cage and existing Centennial Gymnasium are planned to be completed at the beginning and end of the overall project schedule respectively. The goal of this analysis is to perform an in-depth re-structuring of the project schedule to group similar renovation activities in the Wrestling Cage and existing Centennial Gymnasium and re-sequence dates for turnover to EHS.

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PROJECT BACKGROUND

Episcopal High School (EHS) is one of the premier private high schools in the nation, distinguishing itself among the most prestigious academic and athletic facilities. Red-brick façades and large white columns at the entrances, as shown in Figure 1, are a consistent theme among the buildings on the EHS campus. This project includes a 60,000 SF new gymnasium addition as well as 39,000 SF of renovation work to the existing gymnasium and wrestling facilities. The project is slated to achieve a LEED Certification upon completion.

FIGURE 1: Existing Centennial Gymnasium

The new Centennial Gynmnasium addition will fill a void between the existing gymnasium and the Flippin' Field House (indoor track facility). The new facility will mirror the exterior appearance of the existing Centennial Gymnasium. A new auxillary gym with two full length basketball courts will be housed on the entry level of the new addition, shown in Figure 2, along with an athletics hall of fame and athletic department offices. The lower level of the addition will include team meeting rooms and locker facilities. The structure of the new addition is cast-in-place concrete with large span steel roof trusses. One of the main architectural features is the joining of the new addition to the existing Centennial Gymnasium with a two-story glass atrium. Showing signs of use over the years, the existing Centennial Gymnansium and attached Wrestling Cage is to be completely rennovated with modern equipment and high-end finishes. The lower level of Centennial will house trainer facilities, laundry and equipment issue rooms and visiting team locker rooms. Making room for two full-size mats, the Wrestling Cage mezzanine is to be removed, expanding the facilities size and capability. Overall, the additions and alterations to the Centennial Gymnasium will meet the increased demand for updated training facilities and provide the school with a premier athletic center to hold competitions.

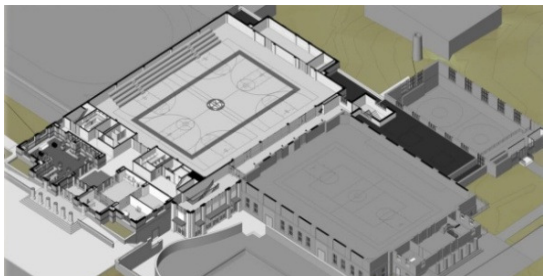


FIGURE 2: New Addition Entry Level Rendering

The largest challenge associated with this project is that the proposed site is located in between two existing structures, shown in Figure 3, on an active private high school campus. The building pad for the New Centennial Gymnasium is located in between to existing structures on the campus. This area is a main through-way for students/faculty as well as active underground utility lines running to the adjacent structures. Among the utilities are major gas, sanitary, storm, water and electrical lines that must remain active

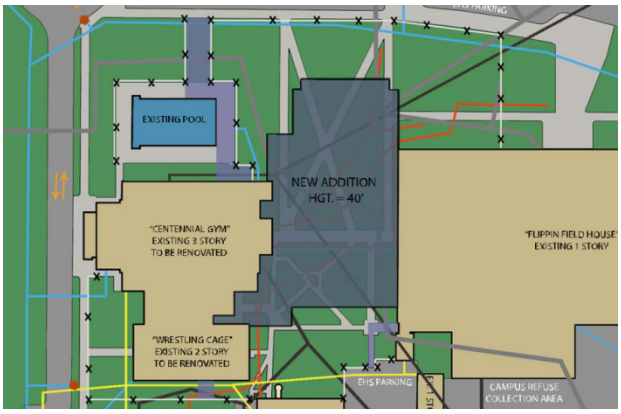


FIGURE 3: Proposed New Addition Site

throughout construction since the adjacent buildings will be occupied during certain phases. In order to construct the new facility, the utility lines had to be removed to allow for excavation and foundation work. Prior to these activities, three months of utility relocation had to occur to ensure that the surrounding campus buildings can remain operational during construction.

The 2009/2010 school year will be impacted by the construction of the new Centennial Gymnasium as well as the renovations to the surrounding buildings. Multiple turnover dates for critical areas, shown in Figure 4, are scheduled throughout the renovation process. The following dates have been set as turnover milestones by DAVIS and EHS to allow use of certain facilities by the athletic department throughout the project duration.

Flippin' Field House: (Renovation)
Turnover to DAVIS: July 1, 2009
Turnover to EHS: July 22, 2009

Existing Wrestling Cage: (Renovation)
Turnover to DAVIS: April 20, 2009
Turnover to EHS: October 9, 2009

Fitness Area/Mechanical Room: (Renovation)
Turnover to DAVIS: October 1, 2009
Turnover to EHS: February 9, 2010

New Gymnasium: (New Construction)
Ground Breaking: June 15, 2009
Turnover to EHS: July 21, 2010

Existing Gymnasium: (Renovation)
Turnover to DAVIS: February 23, 2010
Turnover to EHS: September 3, 2010

FIGURE 4: Turnover Phase Diagram

The main building enclosure system for the exterior wall of the new Centennial Gymnasium, shown in Figure 5, is a modular "Delmarva" face brick backed by structural reinforced masonry bearing walls with 8" CMU's and air cavities. Structural steel lintels are to be utilized at interfaces with the existing structures to support the brick façade. Cast stone masonry sills are to be installed at all exterior windows with cast stone masonry clad units between the entry and upper level windows on the new gym addition. The general sequence for brick façade will be the East/South elevations followed by the North/West elevations. The scaffolding will be erected for the first phase and then repositioned for the second due to the minimal amount of staging and work space on the congested site.

FIGURE 5: Rendering of New Centennial Exterior

ANALYSIS #1: SHIFT FROM NEGOTIATED GMP TO HARD BID LUMP SUM CONTRACTS

PROBLEM IDENTIFICATION

The Centennial Gymnasium project is a negotiated GMP contract, the preferred and standard contracting method for DAVIS Construction, whom prefers to deal with repeat clients with this contract strategy. However, due to the shifting economy and decrease in private sector work, DAVIS has been forced to pursue different markets to obtain other projects, such as public school and government. These projects tend to be competitive lump sum bids and require a shift in strategies to procure the work from unknown clients. This shift has been met with many difficulties and failures due to inexperience with hard bid procurement strategies. Companies across the industry have been faced with this ***critical industry issue*** and continue to struggle in the current economic situation.

RESEARCH GOAL

The goal of this analysis is to investigate the influences that shift companies from one market sector to another and assess the changes in strategies and factors of success/failure these companies encounter when pursuing work from the unknown clients and different procurement techniques.

METHODOLOGY

- Contact DAVIS Construction to receive data for a similar school project under lump sum contract
- Develop/distribute survey for industry members regarding market shift/procurement strategies
- Interview select industry members on key changes in company strategy due to shift
- Compare data for projects under negotiated GMP and those under hard bid lump sum
- Analyze key factors for success/failure when pursuing hard bid projects
- Draw conclusions with similarities among data collected
- Develop a summary of findings and provide possible guidelines for success when pursuing hard bid projects in the current economy

RESOURCES AND TOOLS TO BE USED

- Industry Professionals
- AE 572 contract strategy information
- DAVIS Construction: data from similar school project with hard bid lump sum contract
- Applicable literature

EXPECTED OUTCOME

Understanding that this analysis is much more qualitative as compared to the following technical analyses, it is believed that this study will provide beneficial and interesting insight into the competitive and typically ambiguous world of hard bid projects. Conducting interviews and surveys among several prominent companies should provide the opportunity to derive commonalities among strategies and identify those that tend to provide more successful results in the current economy.

ANALYSIS #2: ELIMINATION OF INEFFICIENCY THROUGH USE OF PREFABRICATION

PROBLEM IDENTIFICATION

Site congestion is a major concern identified on this project. This issue has impacted several trades and caused delays in excavation, geo-pier installation and masonry work to date. The lack of material storage and lay-down space has caused contractors to work inefficiently and unsafely. More than once, a trade had to demobilize until the site cleared up to allow for productive work. Currently, the masonry trade is occupying the most space on site and encountering many delays due to inefficient work. The current exterior wall construction is a modular "Delmarva" face brick backed by structural reinforced masonry bearing walls with 8" CMU's and air cavities

RESEARCH GOAL

The goal of this analysis is to perform a preliminary design of a precast masonry wall system and assess the impacts on schedule, cost and trade coordination on site.

METHODOLOGY

- Research current precast masonry panel systems and select applicable manufacturer
- Contact manufacturer for design consultation
- Design preliminary precast system for exterior facade of New Centennial Gymnasium
- Analyze how the precast system impacts existing structure and design necessary connections
- Assess impact on window and curtain wall interfaces
- Determine transportation and erection requirements for precast panels
- Analyze schedule, cost and constructability impacts of precast system
- Analyze site congestion and trade coordination improvements
- Contact Architect for aesthetic implications/concerns (time permitting)

RESOURCES AND TOOLS TO BE USED

- Industry Professionals
- Precast Panel Manufacturer
- AE Faculty – Structural
- Cannon Design – Project Architect/Structural Engineer
- DAVIS Project Team – Site coordination/logistics
- Applicable literature
- RAM Structural System Software

EXPECTED OUTCOME

After completing extensive research and an in-depth design, it is believed that a precast masonry panel system will effectively reduce the masonry schedule and improve the trade coordination to eliminate inefficiencies due to site congestion. While the precast system may prove to be more expensive than the hand-laid masonry, the savings in schedule should cover the added costs.

ANALYSIS #3: FEASIBILITY AND DESIGN STUDY FOR PHOTOVOLTAIC ENERGY SYSTEM

PROBLEM IDENTIFICATION

The Centennial Gymnasium project is slated to achieve LEED Certification upon completion. However, the project has utilized very few sustainable techniques that could provide a financial benefit to Episcopal High School. Features such as photovoltaic (PV) roof panels were identified as possibilities by EHS in the initial design phases of the project, but eliminated from scope due to perceived financial restrictions. The fact that EHS will own and occupy this facility for over 50 years proves that effective sustainable techniques should be considered for this project.

RESEARCH GOAL

The goal of this analysis is to perform a preliminary design of a building integrated PV energy system and determine the financial feasibility to incorporate the system into the existing power plan to reduce energy costs for the owner.

METHODOLOGY

- Research PV panel technologies and sustainable design techniques
- Contact PV panel manufactures for design consultation
- Determine quantity of panels to be placed on roof and amount of kWh able to be produced
- Analyze how the existing structure will be affected with added PV panel loads
- Analyze how the PV system will connect to the existing electrical power system
- Perform feasibility analysis on life-cycle cost and payback period

RESOURCES AND TOOLS TO BE USED

- Industry Professionals
- AE Faculty – Structural, Electrical
- Cannon Design MEP Engineers/Designers
- Dr. Riley – AE 597D (Sustainable Design Techniques) Professor
- Financial Model spreadsheets from AE 572
- Applicable literature

EXPECTED OUTCOME

Through extensive research and design, it is expected that a building integrated photovoltaic energy system will provide EHS with an attractive financial benefit through reduction in power grid dependency. It is not feasible to produce all of the building energy loads with the PV system; however a significant portion will be accounted for with the renewable energy source. It is believed that the financial model will prove that the PV system is affordable and financially beneficial due to government incentives, rebates and life-cycle cost considerations.

ANALYSIS #4: REDUCTION OF SCHEDULE THROUGH RENOVATION PHASE RE-SEQUENCING

PROBLEM IDENTIFICATION

As described in the project background section, the renovation work on the project is spread throughout the entire schedule with multiple phased occupancies. Specifically, the Wrestling Cage and existing Centennial Gymnasium are planned to be completed at the beginning and end of the overall project schedule respectively. This plan has required several contractors to mobilize, demobilize and remobilize multiple times due to gaps in the schedule and has created uncertainty pertaining to responsibilities and coordination in each area. Also, the phased occupancies require several systems, such as HVAC and fire suppression, to be either temporarily connected or out-of-service during initial turnovers due to incomplete renovation work that tie into later activities.

RESEARCH GOAL

The goal of this analysis is to perform an in-depth re-structuring of the project schedule to group similar renovation activities in the Wrestling Cage and existing Centennial Gymnasium and re-sequence dates for turnover to EHS.

METHODOLOGY

- Interview DAVIS project team for sequencing and trade coordination issues
- Research material availability and resource leveling to determine production capabilities
- Contact subcontractors to discuss activity durations and man-power requirements
- Re-sequence schedule to group similar renovation activities
- Evaluate trade coordination and develop sequencing diagrams for work flow
- Assess impact on EHS school calendar and athletic activities
- Calculate savings in general conditions and management fees due to reduced schedule

RESOURCES AND TOOLS TO BE USED

- Industry Professionals
- DAVIS Project Team
- EHS Representative
- Applicable literature

EXPECTED OUTCOME

It is expected that the majority of the renovation work can be completed simultaneously at the beginning of the project, primarily over the summer months with some finishes occurring at the beginning of the 2009/2010 school year. This will minimize the impact on school functions, allow subcontractors to perform similar activities at the same time, eliminate the phased occupancies and temporary HVAC/fire suppression systems. It is believed that the new Centennial Gymnasium can be constructed as originally scheduled because the excavation, foundation and superstructure activities will not affect the renovation work in the other areas. It is believed that this re-structuring will reduce the overall schedule and turn-over the renovated areas earlier in the project, thus resulting in a savings from general conditions.

ANALYSIS WEIGHT MATRIX

The weight matrix, shown below in Table 1, depicts how each analysis accounts for the four main core areas of investigation. The percentages represent expected time and effort that will be allocated for the core areas in each respective analysis.

ANALYSIS DESCRIPTION	RESEARCH	VALUE ENGINEERING	CONSTRUCTABILITY REVIEW	SCHEDULE REDUCTION	TOTAL
SHIFT IN CONTRACT STRATEGIES	20%	-	-	-	20%
PREFABRICATED SYSTEM	-	10%	10%	10%	30%
PHOTOVOLTAIC SYSTEM	10%	10%	10%	-	30%
RE-SEQUENCING OF RENOVATION PHASES	-	-	10%	10%	20%
TOTAL	**30%**	**20%**	**30%**	**20%**	**100%**

TABLE 1: Weight Matrix for Distribution of Core Areas of Investigation

TIMETABLE

In order to stay on task and meet project goals, a preliminary semester timetable has been developed to schedule work progression for each technical analysis. See ***APPENDIX B*** for the spring semester preliminary timetable.

CONCLUSIONS

Through in-depth research and thorough investigation, the proposed technical analyses will provide a comprehensive review of improving efficiency in the construction industry. It is expected that several trends in procurement techniques for hard bid lump sum projects will be indentified and aid companies in aligning resources more efficiently during the bid process. The prefabricated brick panel system will reduce site congestion and increase productivity for all trades involved. Integrating a photovoltaic energy system in to the building will reduce energy costs for the owner and add to the sustainable features of the project. Finally, re-sequencing the renovation phases of the existing facilities will eliminate trade confusion and reduce the overall project schedule, thus producing savings in general conditions.

This proposal is intended to be a working submission with revisions expected based on feedback from the thesis consultants.

APPENDIX A: BREADTH TOPICS AND MAE REQUIREMENTS

BREADTH TOPICS

The following topics involve a more detailed analysis in distinct technical disciplines within the major. Each topic contributes to one of the previously mentioned analyses, which are indentified accordingly.

STRUCTURAL BREADTH: *Contributes to both Technical Analysis #2 and Technical Analysis #3*

The current roof of the new Centennial Gymnasium is metal decking atop 107' long span steel trusses with no additional equipment housed on the roof structure per the contract documents. The remainder of the superstructure is cast-in-place concrete columns, beams and elevated slabs with load bearing masonry walls.

The substitution of load bearing masonry walls with precast panels, as proposed in *Technical Analysis #2*, will be analyzed to determine the effects on the existing structure. As proposed in Technical Analysis #3, the addition of photovoltaic panels on the roof will require a structural analysis to determine loading and support requirements. Any additional support and connections that are determined to be required for both the precast panels and photovoltaic array will be designed and evaluated for cost/schedule impacts.

RENEWABLE ENERGY/ELECTRICAL BREADTH: *Contributes to Technical Analysis #3*

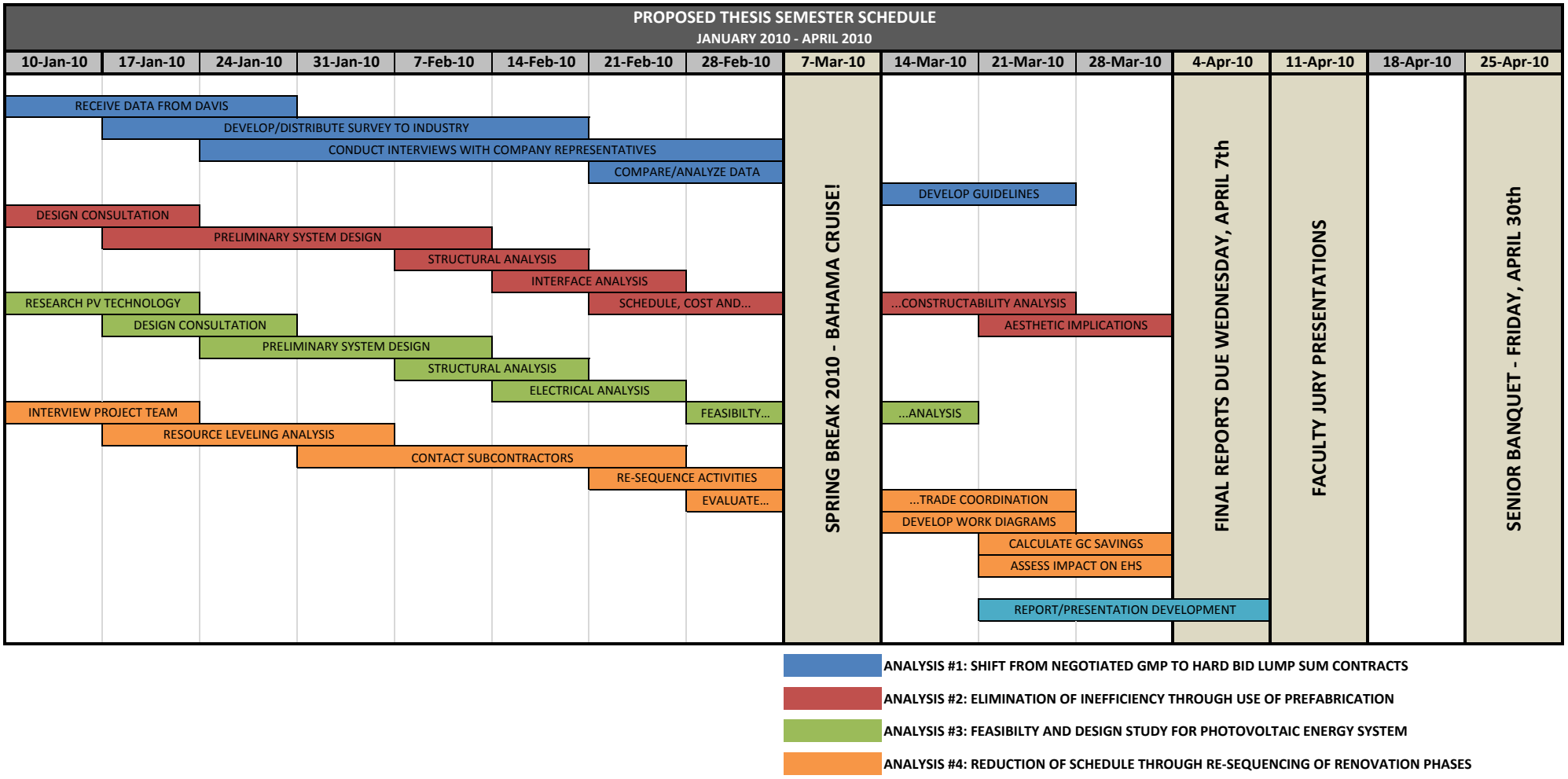
The power distribution system for the Centennial Gymnasium is an existing 480Y/277, 3-phase, 5-wire, 60 hertz feed supplied by an exterior Dominion Virginia Power Company transformer. Currently, all energy is pulled off of the public power grid and channeled throughout the facility.

Integrating renewable energy from a photovoltaic array into the existing energy system will be analyzed to determine the electrical equipment and connection requirements. The electrical system shown on the contract documents will be altered to allocate a tie-in location for the renewable energy source. Additionally, a constructability review will be performed to ensure that the current electrical system is suitable for the requirements of the photovoltaic array.

MAE REQUIREMENT

The MAE requirements of this project will be fulfilled through the feasibility analysis and design of the photovoltaic system. Methods taught in AE 572: Project Development and Delivery Planning will be used to create a life-cycle cost analysis to determine the feasibility of the system and financial benefit to the owner. Additionally, topics discussed in AE597D: Sustainable Building Methods will be utilized to design the photovoltaic array for optimum performance.

APPENDIX B: SPRING SEMESTER PRELIMINARY TIMETABLE


PROPOSED THESIS SEMESTER SCHEDULE
JANUARY 2010 - APRIL 2010
10-Jan-10
17-Jan-10
24-Jan-10
31-Jan-10
7-Feb-10
14-Feb-10
21-Feb-10
28-Feb-10
7-Mar-10
14-Mar-10
21-Mar-10
28-Mar-10
4-Apr-10
11-Apr-10
18-Apr-10
25-Apr-10
RECEIVE DATA FROM DAVIS
DEVELOP/DISTRIBUTE SURVEY TO INDUSTRY
CONDUCT INTERVIEWS WITH COMPANY REPRESENTATIVES
COMPARE/ANALYZE DATA
DESIGN CONSULTATION
PRELIMINARY SYSTEM DESIGN
STRUCTURAL ANALYSIS
INTERFACE ANALYSIS
SCHEDULE, COST AND...
RESEARCH PV TECHNOLOGY
DESIGN CONSULTATION
PRELIMINARY SYSTEM DESIGN
STRUCTURAL ANALYSIS
ELECTRICAL ANALYSIS
FEASIBILTY...
INTERVIEW PROJECT TEAM
RESOURCE LEVELING ANALYSIS
CONTACT SUBCONTRACTORS
RE-SEQUENCE ACTIVITIES
EVALUATE...
SPRING BREAK 2010 - BAHAMA CRUISE!
DEVELOP GUIDELINES
...CONSTRUCTABILITY ANALYSIS
AESTHETIC IMPLICATIONS
...ANALYSIS
...TRADE COORDINATION
DEVELOP WORK DIAGRAMS
CALCULATE GC SAVINGS
ASSESS IMPACT ON EHS
REPORT/PRESENTATION DEVELOPMENT
FINAL REPORTS DUE WEDNESDAY, APRIL 7th
FACULTY JURY PRESENTATIONS
SENIOR BANQUET - FRIDAY, APRIL 30th
ANALYSIS #1: SHIFT FROM NEGOTIATED GMP TO HARD BID LUMP SUM CONTRACTS
ANALYSIS #2: ELIMINATION OF INEFFICIENCY THROUGH USE OF PREFABRICATION
ANALYSIS #3: FEASIBILTY AND DESIGN STUDY FOR PHOTOVOLTAIC ENERGY SYSTEM
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