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Penn State AE Senior Thesis

The West Fuala Expansion

Abu Dhabi, PA

Final Proposal Report

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Executive Summary:

This Senior Thesis Final Proposal will demonstrate and breakdown the 4 proposed analyses which will be performed on the West Fuala Plant Expansion. The purpose of these analyses will be to develop and research a more efficient and better design than the original along with studying new sustainable technologies; all these analyses will be conducted within four core requirements: Critical Issues Research, Value Engineering Analysis, Constructability, Review, and Schedule Reduction.

Analysis 1: Feasibility of Incorporating Solar Photovoltaic Systems

Through energy calculations and process equipment requirements; The West plant's energy consumption is expected to be extremely high. Since the process equipment are custom made where the electric feed/input that cannot be reduced; the only method to reduce energy usage would be to create another sustainable energy source; Hence, the photovoltaic panels. This will reduce the load and the electric usage from the grid. The goal is to be able to power at least one minor system completely and independently in addition to having an early payback period for the panels.

Analysis 2: Structural modification to a Precast Mezzanine

The majority of the West Expansion will be constructed from concrete with the exception of the steel Mezzanine. Having a project entirely from a specific material would be easier and faster to construct; on the other hand, having to build a project with many different types of materials and trades would not. For that reason, the second proposed analyses would be to change the Mezzanine from steel to precast concrete in order to be able to simplify the construction process and be able to save time and cost.

Analysis 3: Bathroom Prefabrication

According to the project team and project schedule, the bathroom/locker area has around 11 tasks that will take place within the same dates in the same area. The main task as requested by the project team was to prefabricate the piping system in the bathroom. This analysis will pursue this in addition to the possibility of attaining more advantages and benefits.

Analysis 4: Conceptual Energy Modeling for Early Design Decisions

Through the use of conceptual energy modeling for early design decisions, the project itself can be studied in the first stages through Project Vasari to be able to reach a more sustainable building with a reduced energy usage than the original. This analysis will explore that along with its effects and potential benefits

Project Background:

Building Name	The West Fuala Plant Expansion
Location	Abu Dhabi, PA
Owner	Private Entity (Confidential)
Purpose of Building	Industrial food production facility
Gross Facility Area	350,545 SF
Number of Stories	½ basement + Main Floor + Mezzanine
Construction Dates	Jun 2010 – Feb 2012
GMP contract	$83 Million
Project Delivery Method	Design-Bid-Build

Table 1 - Project Overview

The West Fuala plant expansion project is an expansion of the original 208,237 SF facility which is over a century years old. The expansion will cover an area of 324,403 SF and will be constructed on the western wall of the original facility. The Eastern side will be attached to the old facility where there will be an open area between the two structures. The old structure would eventually become an office building while the new facility will take the role of production of this plant.

The building phase started on the June 2010 and is planned to be completed on Feb 2012 where it will production will begin as soon as the building is completed. The building consists of a basement along the southern side of the building, a first floor plan with an area of 207,765 SF and a mezzanine within the enclosed building with an area of 40,286 SF.

The basement will have an overall cast-in-place concrete structure while the first floor would be an overall precast system. The mezzanine will be supported on the first floor's precast wall using steel HSS beams which would run along the western wall of the old facility and overlooking the first floor below from the western side.

The original facility is located on an open area relatively isolated from everything around it. There are no building surround it directly nor are there any traffic obstacles that the project team may face during construction. The city has similar weather conditions to the city of Harrisburg in which the winter could have adverse effects on construction.

A design-bid-build delivery method has been chosen as a result of many factors. However, the main issue with this system was that there was minimal interaction between the project team since the designers have independently designed the facility, after which it was out for bidding and then to be constructed by Turner.

BIM has been used in this project for its most basic uses which is 3D coordination of the MEP systems, specifically clash detection. Biweekly meeting were conducted between the BIM coordinator and the team. BIM was also used for facilities management purposes. The model would be able to show where there are clearance issues with the equipment. At the end of the project, the model would be turned over to the owner and the process engineers so that they can use it for facilities management purposes in addition to helping the owner coordinate their process equipment

The Structural envelope of the facility was designed to be a precast concrete system except for the basement which was constructed using cast-in-place concrete. The mezzanine of the facility was erected using Hollow Structural Steel. Steel was chosen mainly since the MEP penetration would have to be known earlier when procuring the precast members; but since that was not possible, the structure was redesigned to steel since it does not require prior knowledge of the MEP penetrations.

Figure 1 - Site Bird-Eye View

Analysis 1

Feasibility of Incorporating Solar Photovoltaic Systems

*See Appendix A for Electrical breadth

Problem Identification:

The main reason behind developing this idea was that this facility consumes major quantities of energy in order to operate the building itself as a structure. In addition, there is the operating cost of the process equipment that is housed in this facility which will be producing the sellable goods. Those two separate systems will all together consume major amounts of energy throughout the life of this building.

Moreover, initially the project team was targeting achieving a LEED certification for this facility. However, since the LEED rating system does include the operating cost of a facility, the facility will not be able to achieve a LEED certification as a result of the extensive major amounts of energy that will be consumed during the plants' operation; Hence, the idea of the solar Photovoltaic panels.

Goal:

Even though a LEED certification would still not be possible; the idea of incorporating a solar photovoltaic system would help reduce the electric consumption by a portion of the total amount. The analysis would take into consideration the cost savings of energy produced and the payback period of this system. The final outcome of this analysis is determining the feasibility of incorporating a solar photovoltaic system into the West Fuala Plant Expansion facility.

Procedure:

- Analyze the cost of Photovoltaic This will include:
    - Immediate actual cost of system
    - Long term cost of system
    - Construction cost of system
        - Equipment
        - Material
        - Machinery
        - Storage cost

        - Labor
        - Transportation cost of each system
        - Environmental cost – long term
            - Analyze protective methods that could be followed to maintain the photovoltaic operation in the Fuala plant.
        - Research the most developed photovoltaic technology and see which would be the best fit for this specific project. This would include:
            - power outage
            - Manufacturer
            - Cost
            - warranties

- Study and compare the duration impact of both systems on the project schedule. The following factors will be included in the analysis.
    - Logistics
    - Labor
    - Placing time
    - Critical path alteration
- Analyze other factors of the both entire systems such as safety, logistics, sequencing and so on.
- Conduct a solar study on the West expansion in order to measure and analyze the amount of solar energy that could be harvested and collected to produce the electrical energy necessary to power a small portion of the entire facility (for instance use the energy to light the electrical lighting fixtures).
    - Study optimum angles of solar energy
    - Study directions of solar energy for the photovoltaic panels.
    - The amount of energy that can be generated over a given area of the roof
    - Study the best location to place the PV panels on the building to harvest the maximum energy possible
- Study the best way to connect the PV system to the current electrical system to be used in the facility (lighting, ventilation… etc.)
- Develop a brief cost analysis determining the financial benefits and the payback period.

Possible Resources:

- Previous projects with similar intentions
- Manufacturers of Solar Photovoltaic Panels
- PSU AE faculty
- Turner representative
- Engineering Library
- Online resources

Projected outcome:

This analysis will comprehensively investigate the practicality of incorporating PV panels to generate electricity. The anticipated outcome of this analysis would be that the PV panels would not be able to generate all energy required to operate the process equipment or the operational cost of the building itself. However, it is anticipated that it would be able to cover a fraction of the expenses of the building systems (not the process equipment) which would help to reduce the cost and the load on the main electrical systems being utilized to power and operate the facility. In addition, it is expected that the financial analysis will show that this system would be financially affordable and worth the payback period.

Analysis 2:

Structural modification to a Precast Mezzanine

*See Appendix A for Structural breadth

Problem Identification:

For an industrial facility, having a steel design of the structure is much easier to design and construct compared to a precast concrete structure which requires more planning, coordinating and communicating with the other engineer and designers. However, since the entire facility's structure would be constructed using concrete; and since there are major procurements of precast members for the envelope of the facility; it is an advantage to construct and design a precast mezzanine along with the rest of the building. In addition, a precast plant is favored over a steel structures plant for hygiene issue.

Goal:

The goal of this analysis is to redesign the structural system of the mezzanine to achieve a much easier system to construct and procure in addition to reducing the overall cost and schedule duration of the project.

Procedure:

- The study will be performed initially on a typical bay which would then be expanded to the entire area of the mezzanine.
- Analyze the cost of switching from steel to precast. This will include:
    - Immediate actual cost of both systems
    - Long term cost of both systems
    - Construction cost of each system
        - Equipment
        - Material
        - Machinery
        - Storage cost
        - Labor
        - Shakeout and laydown areas
        - Transportation cost of each system
        - Environmental cost – long term

- Study and compare the duration impact of both systems on the project schedule. The following factors will be included in the analysis.
    - Logistics - rearranging
    - Labor difference
    - Placing time
    - Critical path alteration
    - Efficiency of workers
- Analyze other factors of the both entire systems such as safety, logistics, sequence and so on.

Possible Resources:

- Previous projects with similar intentions
- Precast system manufacturers
- Turner Projects representatives
- PSU AE faculty
- Engineering Library
- Online resources
- Steel fabrication company
- Available schedule time and estimates for structural system construction.

Projected outcome:

The anticipated outcome of this analysis is that the suggested precast system would have an overall advantage when compared to the current structural system. The comparison between the two systems will be with regard to the construction management portion of the systems which includes cost, schedule duration, logistics, safety and so on.

Analysis 3:

Bathroom prefabrication

10.0 Problem Identification:

The main issue that this problem is intended to solve is that there will be many trades on site in the bathroom/locker area on the second floor in area O that will start simultaneously. For that reason, the use of prefabrication in the bathroom would be studied. The bathroom is designed to have CMU walls with embedded piping and electric rough-ins.

10.0.1 Goal:

The Main objective of this analysis is to be able to solve the issue stated above through the use of prefabrication of the bathroom walls which will have the piping and electricity embedded with a precast concrete wall. This idea was brought up since the entire project is a precast concrete erected project with many of the precast concrete members prefabricated with MEP penetrations and embedded piping and wiring.

10.0.2 Procedure:

Develop an analysis that studies all the aspects that will decide on the feasibility and applicability of this analysis.

- Study what parts can be prefabricated from the bathroom/locker area
- Site Logistics and Hoisting of the prefabricated walls
- Connections of the precast system to the structure
- Tasks after locating and installing walls
- Benefits to prefabrication
    - Quality, environment, less waste
    - Schedule
    - Cost / General Conditions
- Applicability with BIM

10.0.3 Possible Resources:

- Previous projects with similar intentions
- Educational Background from previous AE courses
- PSU AE faculty
- Engineering Library
- Online resources

10.0.4 Projected outcome:

The project projected outcome is that this analysis will prove to prevent congestion, which is the main issue to solve from this analysis, and save time majorly in addition to many advantages that will be gained. Cost could also be reduced if this research was implemented correctly at an earlier time.

Analysis 4

Conceptual Energy Modeling for Early Design Decisions

7.0 Problem Identification:

The initial Fuala plant has operated for around 100 years and has delivered products for all that duration. The west Fuala plant expansion will take the role of the original facility of operating 24/7 to produce the major good to be sold around the globe; hence, it would be very important, helpful and beneficial for the owner and the process engineering team overlooking the equipment and its facility to study the energy costs of production, efficiency and effectiveness of the equipment and process being used.

7.0.1Goal:

The goal of this analysis would be to understand the effect of Conceptual Energy modeling for early design decision making. The method of conducting this would be explored in addition to cost, schedule and possible design changes that would affect and change the design of the building to better result.

7.0.2 Procedure:

- Find out the necessary tools needed to perform this analysis
- Study and understand the program and possible design change
- Conduct a solar study using the program
- Recommend a design change through the use of Energy Analysis

7.0.3 Possible Resources:

- Auto-Desk Project Vasari
- Educational Background from previous AE courses
- PSU AE faculty
- Engineering Library
- Online resources

7.0.4 Projected outcome:

The anticipated outcome of this analysis would be that applying Energy analysis to a project and then delivering it to the owner would have many advantages that the owner and the facility management team would benefit from in the long run in addition to the benefits that will be achieved in the design development phase.

Weight Matrix:

The table below illustrates the way in which time and effort will be dedicated to each of the analyses proposed for the spring semester. The following core areas of investigation will be addressed as appropriate to each analysis: Critical Issue Research, Value Engineering, Constructability Review, Schedule Reduction/Acceleration Proposal.

Analysis	Research (%)	Value Engineering (%)	Constructability Review (%)	Schedule Reduction (%)	Total (%)
PV systems	5	10	10	5	30
Precast Mezzanine	5	10	10	5	30
Turnkey Delivery	15	-	-	5	20
Engineering Analysis (BIM)	15	-	-	5	20
Total (%)	40	20	20	20	100

Table 2 - Weight Matrix

Conclusion:

The West Fuala plant expansion is an industrial facility that operates 24/7 all the time and is expected to operate for many years to come before another one would be constructed. Hence, these analyses and the thorough research that will come along with them will provide valuable information for me as an AE student taking a senior thesis design class in addition to the future senior AE students.

Appendix A

Breadth Topics

Breadth Topics

Electrical Breadth: Technical Analysis 1

The cost of operating the building systems along with the operating cost of the process equipment in this facility is very high. So much that pursuing a LEED certification was not possible anymore as a result of the high operation cost.

The electrical breadth will study the practicality of incorporating solar photovoltaic panel into this project in order to generate electricity which would reduce the energy cost and usage from the electrical grid. Calculations will be done to find the most efficient and effective way to place the panels. In addition, calculations will be made to figure out the amount of energy that could be generated along with the upkeep cost.

Finally, the cost implications of installing this system will be analyzed to determine the feasibility and effectiveness of this system.

Structural Breadth: Technical Analysis 2

As a result of the issues that occurred during the fabrication process and the design process of the facility; the mezzanine was designed and constructed from steel structures.

This breadth will investigate the practicality of changing this structure from steel to a precast concrete system. The analysis will be performed using structural calculations which will show the requirements of switching the system to a precast concrete system. In addition, those calculations will show the dimensions and details of the precast members that will replace the current steel system. This will include all type of load calculations that may affect the mezzanine.

Appendix B

Time Table