Ian Bower

Revised Senior Thesis Proposal

The Concordia Hotel

3/29/2013

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Executive Summary

The main purpose of the Senior Thesis Proposal is to provide readers with a project background which is followed by an identification and overview of the four research analyses areas to be performed, over the duration of the spring semester, on the Concordia Hotel project. For each analysis topic, the problem and the goal are clearly defined. For each analyses the research that will be performed, the potential solutions and the outcomes and resources that will be used to gain these outcomes is discussed. A weight matrix at the end of the report, following the technical analyses descriptions, illustrates how efforts will be distributed among the four analyses and how they meet the core requirements as the following: research; value engineering analysis; constructability review; and schedule reduction. A time table will also be developed to help show the dates of which certain analyses steps will be taken. The timetable will be followed by a description of the breadth topics along with a description of the MAE topic that will be considered. At the end of the course the proposed analyses are presented to the Architectural Engineering Faculty and attending jury members. Below are brief descriptions of the problems, the solution, and the potential benefits of the solutions application. A further description and explanation of these analyses will be presented later in the body of the document.

Analysis 1: Building Information Modeling (BIM) Application to Renovations/Rehabs

There were several key activities that caused increased costs and schedule delays. These problems could have been overcome with greater utilization of BIM to facilitate prefabrication. BIM could be used to consider alternative construction methods through Phase Planning more commonly known as 4D modeling. 4D modeling can likely discover efficiencies in alternative methods and means for delivering the project successfully. This analysis will be considered and applied to help analyze alternative demolition sequences and to apply prefabrication to the extensive Mechanical ductwork systems. The goal is to improve the project's construction efficiency to improve the project schedule and costs.

Analysis 2: Re-sequencing of the Demolition

The demolition of the Concordia project consisted of the removal of MEP systems, drywall partitions, interior finishes and several interior slabs. The demolition initiatives which took place throughout the structure were extensive and repetitious on several floors. Even though demolition of the interior slabs and several structural columns was somewhat repetitious this activity still delayed concurrent and succeeding activities from being completed. These delays resulted in the project being completed behind schedule approximately two months. The goal of this analysis is to consider alternate sequences to demolish the structural slabs and columns in order to accelerate the activities schedule and to result in overall savings to the project.

Analysis 3: Implementation of MEP Prefabrication

The extensive construction and installation of the MEP systems caused extensive delays on the project. The delays resulted in employing crews for overtime work during the week and weekends. These delays and costs could have been avoided if the MEP systems were fabricated at an off-site warehouse and then transported to the construction site using prefabrication techniques. A focus will be placed primarily on the prefabrication of the mechanical ductwork. This will result in several benefits which include cost savings from reduced labor, and prevention of overtime. It will result in greater productivity, safety,

quality and efficiency of materials which will potentially result in greater Leadership in Energy and Environmental Design (LEED) achievements. The analysis will discuss how to achieve the goal of putting the schedule back on track and to reduce construction costs. Since the project is about one month behind schedule, the generated 3D model used for 3D coordination and clash detection can be used to produce clash free shop drawings for MEP prefabrication.

Analysis 4: Alternate Roof Systems

The Concordia Hotel employs two different roofing systems, a green roof and a series of highly reflective pavers in different areas. While installing a green roof has its benefits it resulted in exorbitant structural reinforcements to the top and bottom of the roof slab. Instead of applying a green roof it would have been more beneficial to have utilized a Cool Roof system to capitalize on these benefits without requiring the extensive need for structural reinforcement. The goal of the analyses is to consider the advantages and disadvantages of applying a cool roof as an alternative to the green roof system applied. This analysis will also include a consideration of the effects on construction related to costs, schedule impacts, and constructability issues. Additionally, out of option breadths will arise during this analysis to determine how implementing a cool roof to the tenth floor roof will affect structural and mechanical systems that support the building's function.

Project Background

The Concordia Hotel is an extensive renovation project of the existing hotel located in Washington D.C. The building was originally constructed in 1965 and was in great need of a renovation to its outdated systems. The renovation project of the existing structure will cost $23 million, to the owner which wishes to remain anonymous, where The Turner Construction Company is the General Contractor on the project. The project consists of ten stories, a cellar level and a parking garage and has a size of 80,000 gross square foot and when completed will have 121 studio apartments. The construction of the project started November 2011 and had an original project completion date of December 23, 2011.

The renovation of the Concordia Hotel includes the thorough demolition of the interior and the exterior façade system, MEP systems, and several structural systems that include columns and beams throughout the structure. The construction of the structure will include the extensive installation of 78 Micro Piles in the cellar level of the structure. The construction will also include the installation of a new elevator/stair core and multiple concrete slabs throughout the structure. The structural rehabilitation will also include the implementation of Carbon Fiber Reinforcement Panels (CFRP). The construction will consist of a new façade system. The U.S. Green Building Council, an organization that promotes sustainability in how buildings are designed and constructed, created a certification for green building entitled Leadership in Energy and Environmental Design (LEED). The project is hoping to attain a LEED Gold rating via the utilization of credits associated with sustainable sites, water efficiency, energy & atmosphere, materials & resources, indoor environmental quality, innovation & design process, and regional credits.

Figure 1 Rendering of Concordia Hotel

The site for the renovation is highly restrictive and constraining due to the fact that it is located in downtown Washington D.C. The site where the renovation will take place is surrounded by several existing structures and a narrow alleyway in the rear. The site will need to remain clean in order to allow for delivery trucks and other vehicles to access the site safely. In order to create an efficient means of transporting materials and laborers to each floor a hoist will be erected.

The project experienced multiple construction issues which delayed the schedule by a month and resulted in increased costs. This delay called for the implementation of several analyses to find solutions to these problems to help put the schedule back on track.

Technical Analysis Descriptions

Analysis 1: Building Information Modeling (BIM)

Problem Identification

The successful use of BIM in the 3D coordination of the MEP system clashes helps justify its application to other aspects of the project. The application of BIM to other aspects of the project could have resulted in overall benefits to the project cost and schedule. Several BIM uses are to be considered, analyzed, and compared in terms of potential benefits and ability to increase Return On Investment (ROI). It would have been beneficial to have applied BIM to demolition re-sequencing and prefabrication initiatives to the project. The Pennsylvania State University BIM Execution Planning Guide will be utilized to aid in this thorough analysis and consideration.

Research Goals

The goal of this analysis is to consider BIM's applicability to renovations and not only new construction. Also, to explore and suggest the application of alternative BIM uses which might benefit the project's completion. Upon completion of this analysis, the information discovered through research will be integrated throughout the other technical analyses.

Research Methods

- Acquire AutoCAD models from The Turner Construction Company
- Review model to consider accuracy and thoroughness of the building systems modeled
- Construct any missing systems with the utmost accuracy
- Research how BIM can be used to facilitate renovation project's completion
- Determine how the generated 3D model will be beneficial to the alternative BIM applications
- Research the effect on construction means, methods, and logistics through the consideration of alternative BIM uses
- Gain a greater understanding of BIM's applicability to demolition re-sequencing and prefabrication
- Interview project managers to determine all contributing factors to project delays

Resources and Tools to be used

- The Turner Construction Company project team on the Concordia Hotel
- Dr. John Messner, Dr. Robert Leicht, Dr. Craig Dubler, Dr. Chimay J. Anumba
- The Pennsylvania State University AE Faculty
- Educational background from previous AE courses (such as AE 372, AE 475, AE 476, and AE 570)
- The Pennsylvania State University BIM Execution Planning Guide V2.0
- 3D Software (Revit, Navisworks)
- Applicable literature (books, websites, papers, etc.)
- Key industry members

Potential Solutions and Expected Outcomes

The possible solutions this BIM analysis will find is improvements to construction means and methods and potentially greater efficiency in construction. This research will hopefully have the effect of improving the schedule resulting in savings in overall construction costs. The solution will be that it will create a greater understanding of prefabrication of the main branches of the mechanical ductwork and in the sequence of demolition and construction efforts. Through the research of current construction industry trends it is expected that the information collected will provide accurate data to show positive cost and schedule impacts of implementing BIM methods on a renovation project of this magnitude.

Analysis 2: Re-Sequencing of Demolition Efforts

Problem Identification

The demolition of the Concordia project consisted of the removal of MEP systems, drywall partitions, interior finishes and several interior slabs. The demolition initiatives which took place throughout the structure were extensive and repetitious on several floors. Even though demolition of the interior slabs and several structural columns was somewhat repetitious this activity still delayed concurrent and succeeding activities from being completed. These delays resulted in the project being completed behind schedule approximately two months. The goal of this analysis is to consider alternate sequences to demolish the structural slabs and columns in order to accelerate the activities schedule and to result in overall savings to the project. Three alternative sequences of demolition will be compared to the actual techniques and then considered and analyzed in terms of schedule savings potential.

Research Goal

The goal of this analysis is to perform an in depth schedule re-sequencing in order to make it possible for the owner to turnover floors to construction in a more efficient manner. The ultimate goal is to accelerate the schedule by considering alternative demolition sequences that may accelerate the schedule and allow succeeding activities to begin on-time or ahead of schedule therefore improving the likelihood of the project meeting the required project completion date.

Research Methods

- Interview project managers to determine all contributing factors to project delays
- Conduct interviews of demolition contractor ACEco to understand actual demolition technique as well as potential alternative demolition methods to consider
- Research the effect on construction means, methods, and logistics through the consideration of alternative BIM uses
- Research how BIM can be used to facilitate demolition efforts
- Gain a greater understanding of BIM's applicability to demolition re-sequencing and prefabrication
- Acquire AutoCAD models from The Turner Construction Company
- Review AutoCAD models to consider accuracy and thoroughness of the building systems modeled
- Construct any missing systems with the utmost accuracy
- Determine how the generated 3D model will be beneficial to the alternative BIM applications
- Compose a 3D model of the cast-in-place concrete structural system
- Export the 3D model into Navisworks as a DWG and create a detailed schedule of each of the alternate demolition techniques
- Assess the schedule impact as a result of re-sequencing Analyze potential schedule and cost savings associated with each demolition method

Resources & Tools to be Used

- The Turner Construction Company project team on the Concordia Hotel
- Nathan Lytle with ACEco-Demolition Contractor
- The Pennsylvania State University AE Faculty
- Educational background from previous AE courses (such as AE 372, AE 475, AE 476, and AE 570)
- 3D Software (Revit, Navisworks)
- Applicable literature (books, websites, papers, etc.)
- Other key industry members

Potential Solutions and Expected Outcomes

Upon completion of this analysis, it is expected that a more efficient phasing sequence can be implemented for the demolition and renovation phases. Through an in-depth analysis of the schedule, it is expected that the owner can turnover floors to construction sooner and more efficiently. The organized floor turnover sequence is expected to reduce the overall duration of the schedule, thus reducing overall costs and durations of the project.

Analysis 3: Implementation of Mechanical Ductwork Prefabrication

Problem Identification

The extensive construction and installation of the Mechanical/Electrical/Plumbing (MEP) systems caused extensive delays on the project. Duct banks, electrical bus ways, conduit, telecommunications, and various other components were constructed using a stick-built method that failed to achieve schedule and cost savings potential. The project team has expressed fears that they might go over schedule approximately a month and potentially more due to these extensive delays. In order to stay on schedule, The Turner Construction Company has considered bringing in more tradesmen and employing extra crews during the week and on Saturdays. These overtime crews would include mechanical piping installers and plumbing trim-out crews which would result in a cost of close to $40,000. These delays and costs could have been avoided if the mechanical ducts systems were fabricated at an off-site warehouse and then transported to the construction site rather than applying the typical stick-built method. These components can be manufactured offsite with the proper lengths, sizes and with all the requied connections. After each designated component is prefabricated offsite, they can be delivered, placed, combined and then installed together in order to simplify the installation process. This will result in several benefits which include cost savings from reduced labor and prevention of overtime. It will result in greater productivity, safety, quality and efficiency of materials which will potentially result in greater LEED achievements. The analysis will discuss how to achieve the goal of putting the schedule back on track and to reduce construction costs. Since the project is about one month behind schedule, the generated 3D model used for 3D coordination can be used to produce clash free shop drawings for the prefabrication efforts.

Research Goal

The main goal of this analysis is to perform an in-depth research by exploring options for a lean and green construction approach to material construction, delivery and material storage for the project. Another goal for this analysis topic is to explore the idea and feasibility of implementing prefabricated MEP systems for the construction project. This analysis will consider the impacts on constructability of these systems.

Research Methods

- Acquire AutoCAD models from The Turner Construction Company
- Review model to consider accuracy and thoroughness of the building systems modeled
- Construct any missing systems with the utmost accuracy
- Research how BIM can be used to facilitate prefabrication techniques
- Contact Mr. Matt Corrigan with Pierce Associates Inc.
- Contact Mr. Rhodes with Southland Industries
- Contact mechanical contractor responsible for the installation of key MEP systems
- Determine which components of the MEP system can be easily fabricated to fit together as an assembly within the
- Assess the time required to fabricate and then install assemblies
- Locating and choosing the best prefabrication facility in terms of value not limited to distance and cost
- Research lean practices such as Just-In-Time delivery and production in order to eliminate waste on-site and improve quality and safety

Resources & Tools to be Used

- The Turner Construction Company project team on the Concordia Hotel
- Contact Greg West with Turner and WSP Flack + Kurtz
- The Pennsylvania State University AE faculty
- Owner representatives and construction team
- Prefabrication facilities
- Key industry members
- Contact Mr. Matt Corrigan with Pierce Associates Inc.
- Contact Mr. Rhodes with Southland Industries
- The Pennsylvania State University AE Faculty
- Educational background from previous AE courses (such as AE 372, AE 475, AE 476, and AE 570)
- 3D Software (Revit, Navisworks)
- Applicable literature (books, websites, papers, etc.)
- Other key industry members

Potential Solutions and Expected Outcomes

Upon completion of this analysis, it is likely that a more efficient method of delivering site materials and utilizing space on the jobsite will be determined. It is expected that there will be concerns with the delivery of prefabricated units to the construction site. Upon completion of the analysis it is expected that prefabricated ductwork can reduce site congestion, eliminate waste, improve efficiency and improve site logistics. This analysis will be integrated with the research performed related to Analysis 1. It is expected that there will substantial improvements to constructability, but may add extra costs which can likely be covered by potential cost savings through schedule reductions.

Analyses 4: Alternate Roof System

The Problem

The Concordia Hotel employs two different roofing systems, a green roof and a series of highly reflective pavers in different areas. While installing a green roof has its benefits it resulted in exorbitant structural reinforcements to the top and bottom of the roof slab. Instead of applying a green roof it would have been more beneficial to apply a Cool Roof system to capitalize on these benefits without requiring the extensive need for structural reinforcement. The goal of the analyses is to consider the advantages and disadvantages of applying a cool roof as an alternative to the green roof system applied. This analysis will also include a consideration of the effects on construction related to costs, schedule impacts, and constructability issues. Additionally, out of option breadths will arise during this analysis to determine how implementing a cool roof to the tenth floor roof will affect structural and mechanical systems that support the building's function.

Research Goals

The goal of this analysis is to perform an in-depth study related to implementing a sustainable cool roof, or a green roof system for areas of the roof. The ultimate goal is to determine the benefits to the owner and occupants of the facility, as well as the effect on cost, the project schedule, and the issues of constructability. Additionally, out of option breadths will arise with this analysis when considering the

applicability of a sustainable cool roof, or a green roof system. These other breadths will include; structural and mechanical analyses that will influence the performance and overall functionality of the structure.

Research Steps

- Research various sustainable roofing system technologies and compare the advantages and disadvantages of each of the systems
- Analyze current designs and the energy efficiency associated with each type of roofing system
- Analyze how each different roof type will influence mechanical and structural systems.
- Determine constructability issues, schedule impacts, and perform an in-depth life cycle cost analysis

Potential Solutions and Expected Outcomes

It is believed that applying a cool roof system rather than a green roof system will result in similar benefits and reduce the required costs for structural reinforcement. The application of a green roof system will cost more and require greater structural reinforcement; however, it will allow the building to qualify for greater LEED credits through reduction of the Heat Island Effect and the reduction of storm water runoff. The system will also have increased savings due to its thermal efficiency. Installing the cool roof system to all of the roof's surfaces will likely result in lesser LEED qualifications however it will result in greater cost savings due to the reduced structural needs. Unfortunately, the cool roof system will not be as thermally efficient as the green roof system. This analysis will consider both of these options and to consider which system will result in the greatest benefit to the project.

Resources

- AE Faculty, Key Industry Members
- Owner Representatives and the Construction Team
- Product manuals and Reviews
- Project Drawings and Specifications
- Educational Background from Previous AE Courses, Internship with Dr. Riley
- Knowledge from undergraduate courses (AE 308 and E 404)
- Applicable Literature

Weight Matrix

The four technical analyses that are described in this proposal involve studies based on four core thesis investigation areas including; Critical Issues Research, Value Engineering Analysis, Constructability Review, and lastly, Schedule Reduction/Acceleration proposal. The weight matrix depicted in Table 1 shows the percentages in which the technical analysis areas incorporate these core investigation areas.

1. Critical Issue Research
2. Value Engineering Analysis (VE)
3. Constructability Review
4. Schedule Reduction/Acceleration

Weight Matrix					
Description	Research	VE	Constructability review	Sched. Reduction	Total
MEP Prefabrication	5%	-	5%	10%	20%
BIM Uses	10%	10%	10%	-	30%
Re-sequencing of Demo Efforts	-	5%	5%	10%	20%
Alternate Roof System	10%	10%	5%	5%	30%
Total	25%	25%	25%	25%	100%

Table 1 Weight Matrix

Time Table

To ensure the ability to stay on task and to meet the senior thesis goals, a timetable for the spring 2013 semester has been developed. The table will be utilized to track and assess progress. It will also be used to properly sequence and consider each analysis.

It is essential to use this table as a guideline to schedule items to be completed and the major milestones that should be achieved in order to efficiently complete four technical analyses and two out of option breadths. Maintaining this schedule will assist in remaining on task and organized throughout the spring 2013 semester.

Critical Issues Research Methods

A critical industry issue that applies to the Concordia Hotel project is lean construction. The analyses will apply techniques used to attain a lean construction practice by employing prefabrication techniques to the project utilizing BIM as a valuable asset to this analysis. The analyses will pursue research in this critical industry issue because of the experiences, interests, and experiences at the PACE Roundtable meeting that support its relevance. Throughout the curriculum of the Architectural Engineering Program, experience is provided with lean construction initiatives and sustainable/green design. Throughout the program has been a push to apply more prefabrication and modularization methods because of their ability to improve construction efficiency. The PACE Roundtable event helped justify the application of prefabrication to the project.

Problem Statement

The challenge that faces the industry when it comes to prefabrication is the ability to apply this method to construction. Prefabrication and modularization are becoming more and more prevalent in the construction industry; however, the feasibility of this method still requires some justification. Unfortunately, this method is not always feasible because of the fact that there are not enough facilities that are located nearby a construction site. It is often impractical to apply prefabrication, because the cost of transportation often outweighs the potential schedule and project cost savings.

Goal of Research

The goal of my research is to better understand what prefabrication can truly benefit in concern to the construction industry. My hopes are that I will better understand the need for its application, the benefits that will occur and the areas in which it can be applied. In order to apply this method to my analyses I will need to have a great understanding of how to design for prefabrication, how to plan for offsite fabrication, the design of logistics and lastly production planning.

When researching the design for prefabrication, the analysis will consider the ideas of standardization, design schedule requirements & constraints, and unique considerations. Conducting research on the planning of offsite fabrication I plan to look into the labor and production tradeoff optimization. My research will also analyze transport, transport design and constraints, and erection/placement methods when considering the design of logistics. A thorough analysis will finally be conducted on the sequencing and scheduling for modularization and install coordination requirements related to production planning. These research areas will be compiled in order to comprise a report essentially that can be used for different audiences who may benefit.

I imagine that some of this research can be utilized by any industry members hoping to apply prefabrication techniques to construction activities and key systems on their construction project. The guide can be used by students, faculty and professionals in order to better prepare individuals tackling the somewhat daunting task of applying this method to their project.

Conclusion

Upon completion of the four technical analyses described in this proposal, alternative methods for delivering this project based on a central theme of efficient design and construction will be determined. The goal of these analyses is to suggest areas of improvements in the process of both building construction and operation that can be performed on the Concordia Hotel. The analyses will be performed involving four core investigation areas including Critical Issues Research, Value Engineering Analysis, Constructability Reviews, and Schedule Reduction/Acceleration Proposal. The first analysis, BIM, is to increase efficiency of the construction means and methods, decrease cost, add value to the building and to reduce the schedule. The second analysis, re-sequencing of the demolition efforts is another attempt to increase efficiency of the construction means and methods, decrease cost, add value to the building and to reduce the schedule. The third analysis, MEP Prefabrication, is to help with schedule and cost savings. The fourth analysis, Alternate Roofing Systems, will be applied to the project in order to improve the efficiency of the project. Additionally, out of option breadths will arise during this analysis of replacing the currently proposed green roof system combined with a typical TPO roof system with other roofing alternatives. These analyses will be conducted over the duration of the spring semester and then compiled into a final thesis report and finally the findings will be presented to the AE Faculty and Jury Members.

Appendix A

Breadth Topics

Breadth Topics

In order to demonstrate a breadth of understanding in Architectural Engineering, two breadth studies will be performed to display competency in other disciplines. The following breadths are related to the impacts on the structural and mechanical systems due to the review of a more efficient roofing system.

Structural Breadth

The current designed roof of the tenth floor consists of a green roof system and highly reflective pavers. With the application of a green roof system to the tenth floor, the structural system required extensive reinforcement. When considering a cool roof to replace the green roof system an analysis of the existing members will be made to determine their capability of supporting the cool roof system.

This analysis will satisfy a structural breadth requirement by illustrating skills to perform a structural analysis of the tenth floor roofing system. The structural analysis will consist of determining if the existing system is sufficient and if redesigning the system is necessary due to the loading of the cool roof. Each different roofing type will have different weights and support requirements causing potential reconsiderations of the roofing structural systems. Through the utilization of typical hand calculation methods and the knowledge acquired in my structural analysis classes AE 308 and AE 404 I will conduct an analysis of the structural loading requirements. Each roofing system will have its advantages and disadvantages associated with LEED credits, construction costs and schedule impacts.

Mechanical Breadth

With the construction of a new roofing system to the tenth floor, the current design of the mechanical system may be affected due to the thermal properties of the alternate systems.

This analysis will satisfy a mechanical breadth requirement by illustrating skills to perform a mechanical analysis of the alternate roof systems. The impact of the system will be analyzed in terms of thermal resistance between the alternate roof systems and their impact on the mechanical systems for the project. Through the utilization of typical hand calculation methods I plan to analyze the effect of the alternate roofing systems based on their thermal ratings.

Appendix B

Spring Semester Preliminary Timetable

			1/28/2013 Milestone 1			2/11/2013 Milestone 2			3/1/2013 Milestone 3					3/25/2013 Milestone 4		Ian Bower CM Option Mr. Sowers Concordia Hotel					
Proposed Thesis Semester Schedule January 2013 - April 2013																						
Jan-7-13	Jan-14-13	Jan-21-13	Jan-28-12	Feb-04-13	Feb-11-13	Feb-18-13	Feb-25-13	Mar-04-13	Mar-11-13	Mar-18-13	Mar-25-13	Apr-01-13	Apr-08-13	Apr-15-13	Apr-22-13							
Analyze BIM Success and Applicability to renovations, consider alternate BIM Uses																						
Analyze Catch Plate Demolition Technique																						
	Analyze Staggered Demolition Technique																					
		Analyze Extended Demolition Technique																				
		Analyze Cost and Schedule Savings Potentials With Alternative Demolition Efforts																				
		Research Prefabrication of MEP Systems in Renovations and New Construction		Design Shop Drawings of MEP for Local Prefabrication																		
				Locate and Choose MEP Prefab Facilities Based On Value Added																		
			Analyze Cost and Schedule Savings Potential With Prefabrication																			
				Research Alternate Roofing Systems																		
					Structur	l Breadth																
					Analysis of	oof Systems																
						Mechanical Analysis				Breadth Roofing												
										Analysis of Savings in Project Costs & Schedule, & LEED credits		Tie-Up Loose Ends										
							Submission 4 (2/25/13)	Spring Break					Final Report April 3	Faculty Jury Presentation April 8-12	Senior Banquet April 26							
Milestone				Begin Write-Up				Begin Powerpoint				Final Report										
1	Depth 1 Complete Building Information Modeling (BIM) Analysis							Spring Break		Incomplete			Jury Presentatio									
2	Depth 2 Complete Demolition Re-sequencing Analysis							Submission														
3	Depth 3 Complete Implementation of MEP Prefabrication							Miscellaneous		Complete				ABET Assessment								
4	Depth 4 Complete Alternate Roof System							Finished Work						Update CPEP and Report								