Architectural Engineering 2012 Senior Thesis

Senior Thesis Proposal

Reston Station Phase 1 Garage | Reston, VA

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Executive Summary

This proposal is intended to present 4 topics of construction related analysis for further investigation and research on the Reston Station Phase 1 Garage project. The 4 analyses that will be performed include SIPS and matrix scheduling, MEP design coordination, supply chain and BIM capabilities, and the public-private partnership ownership agreement. These analyses will be developed throughout the spring semester of the 2013 academic year and will be presented to faculty and panel members at the conclusion.

Analysis 1: SIPS and Matrix Scheduling for Trade Sequencing

Short interval production scheduling (SIPS) and matrix scheduling are both detailed ways to evaluate the durations and sequencing of construction trades on complex projects. At Reston Station, design delays have pushed back the critical path which means a delayed substantial completion. In an effort to restore the schedule to original finish date, finish trades must be accelerated. This analysis will utilize SIPS and matrix scheduling to determine the most critical tasks on the schedule and alternative possible sequences to arrive at the original date of completion.

Analysis 2: MEP Design Coordination

The Reston Station development is a multi-phased project that includes 5 commercial, residential, and retail buildings above the 1st phase garage. There are 3 separate A/E teams working on various phases of the project making coordination a huge challenge, particularly with MEP systems. This analysis will investigate different approaches that can be used to better coordinate these teams and systems including both the collaborative efforts and alternate delivery methods. Collaborative efforts include things like co-location and collective goal formation. Alternative delivery could include the award of only one contract for the design of the entire property instead of 3 or more separate ones.

Analysis 3: Utilizing Supply Chain and BIM for Equipment Staging Coordination

Equipment and material staging has become a challenge at the Reston Station job site as a residual effect of delays. Expensive fans and escalators are currently being stored in the project work areas where they are exposed to a significant risk of damage. This analysis will utilize supply chain mapping techniques and 4D modeling to better understand the procurement methods for these long lead time items. The alternative solution of temporarily storing these items in off-site facilities will be analyzed and a conclusion will be determined concerning which solution provides a better outcome for the project goals.

Analysis 4: Public-Private Partnerships

Public private partnerships (PPP) are a relatively new form of dual owner partnership and they rarely occur in commercial building construction projects. This mix of private companies and government bodies creates unique challenges and concerns that should be addressed. This analysis will define what a PPP is, why it was chosen for this project, and how PPP's impact the construction industry and the project on which they exist.

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Project Background

The Reston Station Phase 1 Garage project is the first of several building projects on a development property in Reston, Virginia. The development is being built to take advantage of a future station for the Metro Rail Silver Line Expansion project that will be adjacent to the property. The Reston Station Garage is owned by Comstock Partners and Fairfax County Virginia (a public-private partnership). Comstock has a 99 year lease with the county on the property and holds all of the construction contracts for the project. The garage project consists of a 7 level, 1.3 million square foot underground garage that will accommodate over 3000 personal vehicles as well as a bus terminal and a ride share area.

Davis Construction served as the Construction Manager for the construction of the garage and the delivery method was a Guaranteed Maximum Price (GMP) contract. The project began construction in April of 2011 and is schedule for substantial completion in July of 2013. The construction schedule has been fasto-tracked which means construction can occur concurrently with design. Construction cost of the garage is approximately $95 million.

Excavation on the project took over 10 months and was temporarily delayed due to a seismic event in the area and hurricane Irene. The structural system used for the garage is cast-in-place concrete, the contract to perform this work is approximately a third of the project budget. Mechanical systems in the garage focus on ventilation of the large volume of underground space and almost 1.5 million cubic feet of air are circulated each minute. The interior garage is finished with traffic coating and paint and the majority of lighting is supplied by highly efficient LED fixtures. Finish materials on the plaza level are the aesthetic highlight of the project and include decorative pavers, planters, street lights, and ornate stone façade.

The greatest challenges for the project stem from the fast-track construction delivery and design delays. Concrete design has fallen behind the pace of construction and since the structural cast-in-place system is a key component of the critical path every day lost in progress of the concrete design is a day lost in project completion. Figure 1 shows many aspects of the construction of the garage happening concurrently.

Figure 1: Construction of the Reston Station Garage

Analysis 1: SIPS and Matrix Schedule Analysis of Finish Trade Sequence

Problem Identification

Comstock Partners and Fairfax County, the owners of the Reston Station project, chose to fast track the construction of the garage phase in order to ensure project completion prior to the opening of the Metro Silver Line and maximize revenues through parking fees and bus terminal operation. The design delays of the cast-in-place concrete structure of the garage have caused significant construction schedule consequences. Progress on the project currently faces a 25 day negative float from the baseline schedule and unless finish trades can accelerate the project will be unable to make up the lost time prior to substantial completion. Adding to the complexity of the finish sequence is the 2 levels formed plus 4 levels shored requirement for slab support during construction. This is a rare requirement since most cast-in-place concrete slabs have a 2 plus 2 requirement.

Research Goal

The purpose of this analysis is to identify the most critical tasks in finishing the underground levels of the garage and develop a sequence of tasks utilizing a short interval production schedule (SIPS) and to present this sequence using a matrix schedule.

Approach

- Research and review SIPS theory and utilization
- Identify individual tasks and their durations for finishing a typical bay of the garage
- Investigate what trades can coexist without sacrificing workmanship
- Develop a SIPS model based on findings
- Analyze and develop conclusions on the results
- Compile and present results with illustrations of original versus SIPS modified sequence and a matrix schedule.

Available Resources

- Construction Management Project Team
- AE 473 and 476 course material
- AE Construction Faculty
- Industry Professionals via LYRIS Discussion Boards
- Available case studies and literature

Expected Outcome

The SIPS analysis will reveal which tasks pose the biggest challenge to finishing the underground garage. In addition, a matrix schedule will help visualize the sequence of construction and highlight any possible overlaps or unnecessary lags. In the best case scenario, a more efficient construction sequence will be realized through the creation of these schedule analysis tools.

Analysis 2: MEP System Design Coordination between Multiple Phases

Problem Identification

Due to fast-track construction scheduling and the fact that the garage A/E team is separate from the above ground A/E team it appears that the mechanical system design engineers are "shooting at a moving target". As the design for the office, retail, and residential buildings progress locations for pipes, conduits, and ducts, continuously change. This is especially challenging for the construction team of the garage because they are actively installing the systems beneath the changing areas. If construction continues with the current contract drawings and documents it is very likely that many pipes, ducts, and conduits will need to be demolished and reinstalled to meet the above structures properly.

Research Goal

The purpose of this analysis is to determine the cost and schedule risks associated with building the garage MEP systems without coordinating with final designs from the A/E on the connecting buildings. This analysis will also identify some solutions to this issue and determine the benefits and drawbacks to those solutions. These solutions include awarding the entire complex to one A/E team, or alternatively, encourage the members from each A/E team to co-locate while designing those specific areas of coordination.

Approach

- Study the project drawings to identify problem areas in MEP designs
- Estimate and schedule the added time and cost of core drilling in uncoordinated areas
- Interview project team regarding limitations to more coordinated design alternatives
- Compile and present results

Available Resources

- Interviews with A/E team members
- Construction Management Project Team
- AE Construction Faculty
- Industry Professionals via LYRIS Discussion Boards
- Available literature

Expected Outcome

The anticipated result of this analysis is that even though both solutions will have a measurable impact on the coordination of the systems, the added costs (both direct and indirect) of these solutions is most likely too high to implement. The goals of the owner team were driven by reducing costs and it will be interesting to see the difference in total costs once remedial measures of the re-installation of systems are analyzed.

Analysis 3: Equipment Staging and Material Storage Coordination

Problem Identification

The procurement methods for large equipment did not accommodate the possibility of delays in the project schedule. Specifically, the exhaust and intake fans and the escalators were delivered to the site and were forced to be stored on the concrete slabs in various locations around the building. Storing some equipment on site for a few days is a manageable risk but storing such fragile and expensive materials in the middle of an active construction site for several months is exposing the equipment to excessive dangers.

Research Goal

The purpose of this analysis is to develop a supply chain map of the equipment procurement process and to create a 4D model of the garage during the material delivery stages of construction. These tools will be used to compare the current on-site storage solution to the alternative solution of storing materials in an off-site facility nearby.

Approach

- Research supply chains in construction and supply chain maps
- Develop a supply chain map for the current equipment procurement method
- Develop an alternate solution that incorporates off-site storage
- Determine additional time and cost considerations of the alternate solution
- Create 4D model with Navisworks to illustrate equipment staging scenarios
- Draw conclusions from analysis and present findings

Available Resources

- Construction Management Project Team
- Software tutorials and guides
- AE 372 and 473
- AE Construction Faculty
- Industry Professionals via LYRIS Discussion Boards
- Available case studies and literature

Expected Outcome

The analysis of equipment staging is intended to compare the current staging situation with an alternative solution that includes off-site storage. While this alternative option lowers the risk of damaging the materials and equipment it will result in added costs in both space rental and added transportation.

Analysis 4: Implications of Public-Private Partnerships

Problem Identification

The Reston Station Phase 1 Garage project is owned by a public private partnership (PPP). Comstock Partners is a commercial and high density residential developer in northern Virginia and acts as the private industry partner while Fairfax County is the government owner of the garage property. PPP's have only existed since the early 1990's and are not common in the commercial construction industry. While Davis Construction (the contractor) has only one contract with Comstock Partners, Fairfax County owns the land and is contributing a lot of the funding for the public parking structure. The two owners have their own goals and opinions but have to come to agreement on many issues pertaining to garage design and construction. This relatively new owner configuration has many unique characteristics and by understanding more about PPPs construction professionals can manage the projects that have partnered owners more effectively.

Research Goal

The goal of this analysis is to understand and present how a PPP works, determine the pros and cons of a PPP, and speculate how a PPP can be beneficial in other areas of the American construction industry. Construction Managers and Owners could both benefit from this research because it could provide a solution to many owner concerns and can help construction professionals understand the relationships between owners. Reston Station Phase 1 Garage will serve as a good case study for this analysis.

Approach

- Research public private partnerships
- Interview Reston Station partner members
- Determine connections between PPP's and the garage project.
- Summarize and present results

Available Resources

- Construction Management Project Team
- Fairfax County and Comstock Partners
- AE Faculty
- Industry Professionals via LYRIS Discussion Boards
- Available case studies and literature

Expected Outcome

The anticipated results from this research topic include defining what a public-private partnership is, the reasons one was selected for this specific project, and the benefits and drawbacks to using a PPP on a building project. The research should also reveal trends for future use of partnerships elsewhere in the industry.

Weight Matrix Analysis

The weight matrix of the analysis topics in figure 2 indicates the relative amount of time and effort that is expected to be given to each area of analysis topics.

Figure 2: Weight Matrix

Weight Matrix for Thesis Analysis Areas					
Analysis	*Research*	*Value Engineering*	*Constructability Review*	*Schedule Reduction*	*Total*
SIPS		5%	5%	20%	30%
MEP Coordination	10%	5%	15%		30%
Material Staging Coordination	5%	5%	10%		20%
PPP	20%				20%
Total	*35%*	*15%*	*30%*	*20%*	*100%*

Conclusions

Spring semester will be dedicated to analyzing four depth areas of study that include Short Interval Production Scheduling (SIPS), MEP system design coordination, material staging coordination, and public-private partnerships (PPP). The SIPS construction schedule analysis will allow the construction manager, subcontractors, and owner to understand what items in the finish sequence are critical and how work can best be sequenced through the final stages of construction. Integrated work processes or a sole A/E team could help remedy the MEP design coordination between the multiple phases of construction but the direct and indirect costs of these options must also be considered. In addition, supply chain mapping and 4D coordination of material and equipment staging could assist the contractor in mitigating risks associated with onsite long term storage of those items. Finally, the relatively new owner relationship known as the public-private partnership is an interesting factor in this project and research will be done to determine its benefits, drawbacks, and special considerations. This is a first submission of this proposal and it is likely to be revised upon future reviews.

APPENDIX A

Breadth Topics

Breadth Topics

The two additional analyses presented in this section are designed to demonstrate competencies in other areas of the Architectural Engineering curriculum outside of the construction management option. These breadths are issues for investigation that directly relate to one of the construction management analyses that were previously mentioned

Concrete Slab Redesign to Accommodate Reduced Shoring Requirements

The greatest challenge for schedule acceleration with the finishing trades is the 2 plus 4 shoring requirements for slab support. Typically, structural engineers specify that post shores remain on 2 levels beneath the 2 levels formed under the slab being poured. The extra 2 floors of shoring at Reston Station delay all of the trades from gaining access to those floors at an earlier time.

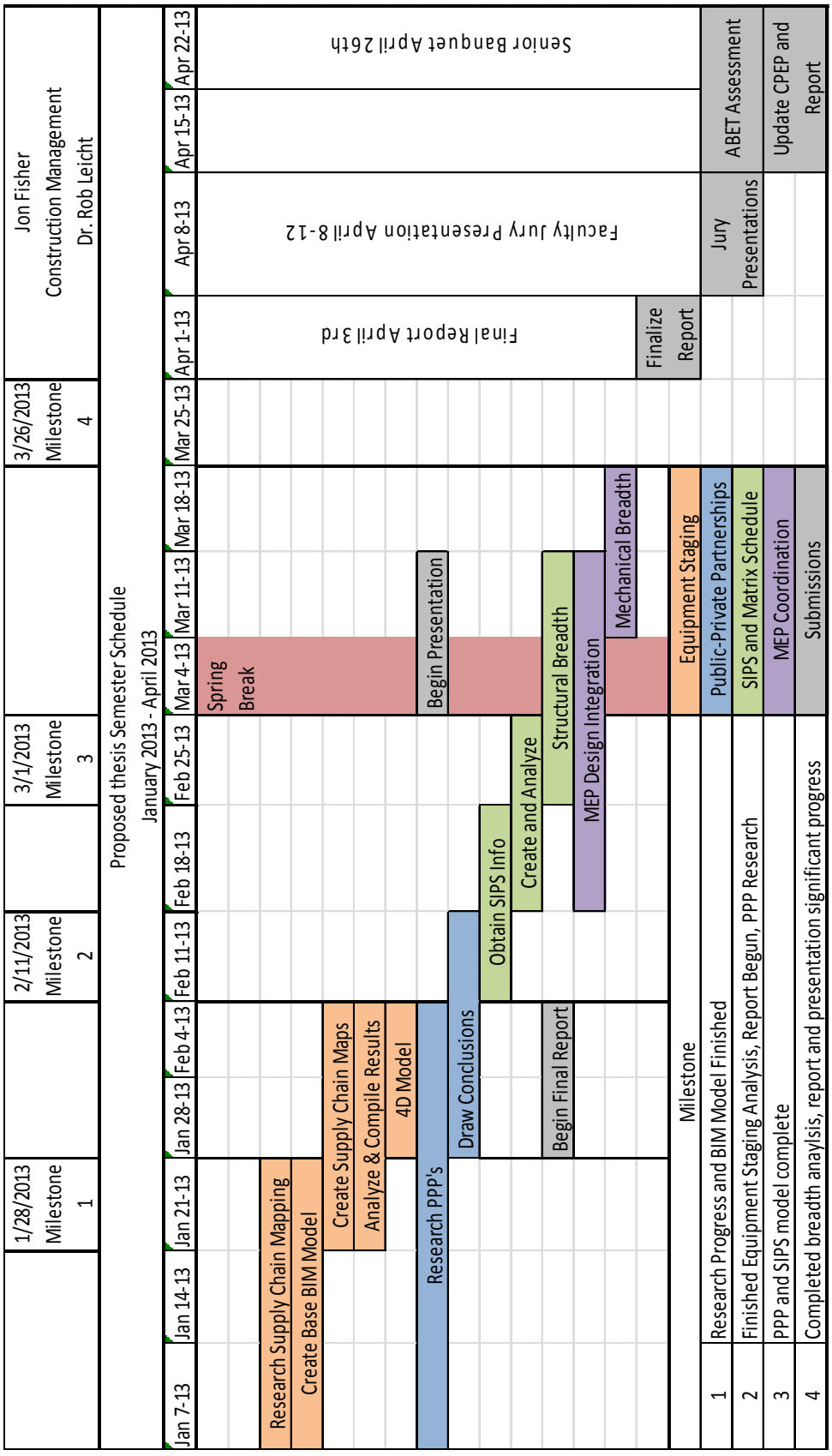
A breadth analysis that would benefit the issue of access to these floors is a redesign of the slabs so that a more typical 2 plus 2 shoring plan would be required. First, research will need to be done to determine the aspects driving the engineering design for the more extensive support requirement. Once it is know what is causing the need for increased support a redesign of the concrete slabs can reduce this requirement. Whether the redesign requires a thicker slab, increased reinforcing steel, or both there will be an increase in material and labor cost. An analysis will be performed to determine this added cost and the approximate savings in schedule that could be a resultant of these changes.

Mechanical System Design Adjustments to Accommodate Design Flexibility

The greatest challenge to design coordination is the changing of A/E teams between one phase of construction and the next. With the next phase on a completely different delivery schedule it is hard for the construction team on the 1st phase of the garage to line up pipes and penetrations with adjacent future buildings. In order to build and accommodate systems for future phases of construction in the present time the only solution is to temporarily cap mechanical, plumbing, and fire sprinkler pipes. This creates issues related to pressure and efficiency of systems and how the system changes from one phase to the next is an important thing to consider. This breadth analysis will first determine the loads that are required by these systems and then compare the pre-cap and post-cap operation of these systems and determine if any notable changes occur.

APPENDIX B

Spring Semester Progress Schedule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Proposed thesis Semester Schedule
January 2013 - April 2013
1/28/2013 Milestone 1
2/11/2013 Milestone 2
3/1/2013 Milestone 3
3/26/2013 Milestone 4
Jan 7-13
Jan 14-13
Jan 21-13
Jan 28-13
Feb 4-13
Feb 11-13
Feb 18-13
Feb 25-13
Mar 4-13
Mar 11-13
Mar 18-13
Mar 25-13
Apr 1-13
Apr 8-13
Apr 15-13
Apr 22-13
Research Supply Chain Mapping
Create Base BIM Model
Create Supply Chain Maps
Analyze & Compile Results
4D Model
Research PPP's
Draw Conclusions
Obtain SIPS Info
Create and Analyze
Begin Final Report
Structural Breadth
MEP Design Integration
Mechanical Breadth
Spring Break
Begin Presentation
Final Report April 3rd
Finalize Report
Faculty Jury Presentation April 8-12
Jury Presentations
Senior Banquet April 26th
ABET Assessment
Update CPEP and Report
Milestone
1 Research Progress and BIM Model Finished
Equipment Staging
2 Finished Equipment Staging Analysis, Report Begun, PPP Research
Public-Private Partnerships
3 PPP and SIPS model complete
SIPS and Matrix Schedule
4 Completed breadth anaylsis, report and presentation significant progress
MEP Coordination
Submissions