

## Construction Option Thesis Requirements:

Fall 2013

Department of Architectural Engineering

AE 481W: Senior Thesis

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### Summary

This document provides a detailed description of the Construction Capstone Project requirements. You are expected to familiarize yourself with the assignments and submit your thesis deliverables on the assigned dates.

### Key Dates / Grading Percentage for Technical Assignments:

25%	<b>Tech 1:</b> Construction Project Management	September 16
25%	<b>Tech 2:</b> Cost and Schedule Analysis	October 16
	<i>PACE Roundtable Meeting (Attendance required)</i>	November 7
20%	<b>Tech 3:</b> Methods Analysis	November 15
	<i>Proposal Presentations</i>	Dec 2 & 4
30%	<b>Final Thesis Proposal</b>	December 11

### Grading

Paper copies of each submission will be due to your advisor to the designated location in the Engineering Units. Electronic copies of each report are to be submitted to your via Turnitin.com. You are also required to electronically post your report per the thesis requirements. Due dates are fixed and final.

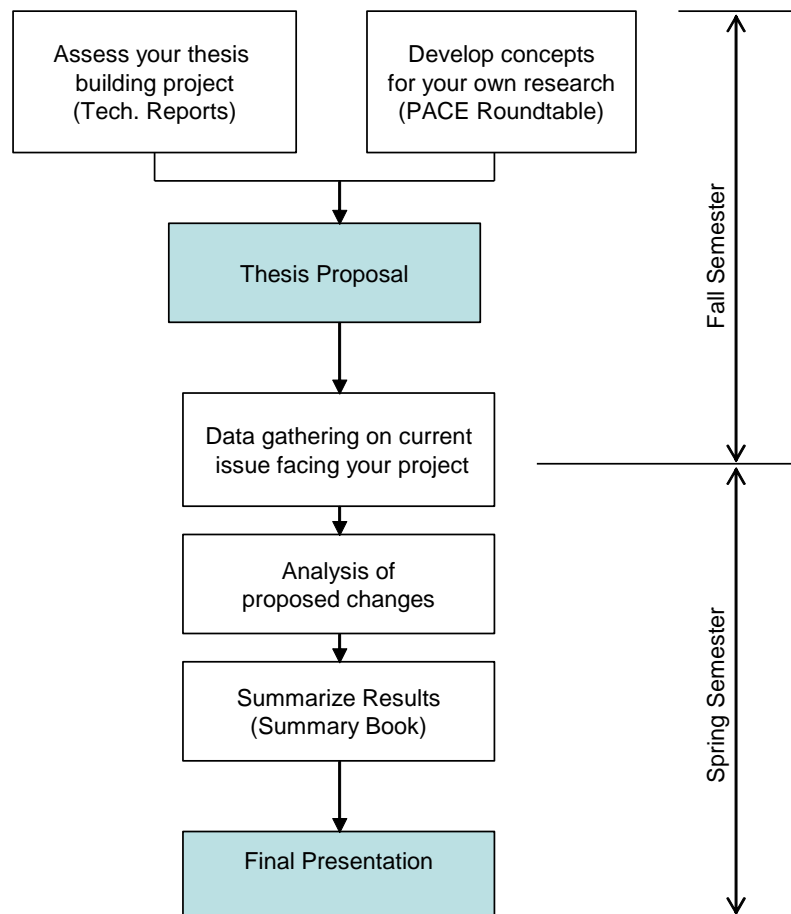
### Corrections to Graded Reports:

Once you receive your returned reports with comments, you are responsible for making appropriate corrections to your assignments and reposting the corrected version on your eStudio website along with re-submitting it to Turnitin for confirmation and to help instructors track changes.

## Thesis Process

### Objectives:

- Gain a working understanding of the technical and construction issues on your thesis building.
- Develop a thesis proposal that defines areas of investigation to be completed in the Spring Semester.
- Gather data through industry sources on key relevant issues facing the building industry and your project, and on the technical systems analysis you perform to identify potential improvements on your project.
- Develop and produce a concise and professional oral and written presentation of your results.



## Technical Assignment 1: Construction Project Management

This portion of your Fall Thesis is intended to familiarize you with the conditions under which your building is constructed and the scope of work. This background will provide you with the opportunities and constraints that affect the design and construction process. Note that some of this information was required in your Building Statistics section posted to your eStudio portfolio. The resulting deliverable has two elements – 1) an executive summary of your project, 2-3 pages in length, and 2) an overview presentation 6-8 minutes in duration to be presented on the date noted in the schedule on page 1.

### (30) ***Executive Summary / Table of Contents / Professional Document***

Prepare a two to three page summary of the key findings, project and system details, and overall project characteristics in this assignment. This should be a stand-alone document, but should also serve as an introduction to your project that you will be able to re-use when compiling your final report in the spring. The content should include highlights from all of the areas noted below, including the project organization, contractual arrangements, construction schedule, and budget. Highlight any distinguishing requirements, e.g., the project is LEED rated, or any unusual techniques that were employed to meet the demands of the project, e.g., unique delivery methods or information technology solutions. Your document should be written as a professional technical report. You should include one or two small images or tables to more easily present critical information about your project, however the written content should make up 2 pages without the images.

### (70) ***Presentation***

Prepare a 6-8 minute presentation with a maximum of 8 PowerPoint slides. Each slide should focus on presenting the visual information. Please submit a printout of the slides in note format (one page per slide with the visual as the top half and the notes as the bottom half) with bullet points or a brief narrative in the notes section that you will use to highlight the critical information, constraints, or findings from each area you study. Attach this as an appendix to your executive summary.

#### (10) ***A. Project Schedule Summary (1 slide)***

Produce a summary schedule of your project using MS Project, Primavera, or Excel. Include the design phase, and procurement of construction services on the schedule. Your schedule should illustrate when the major phases of construction occur (Sitework, foundations, superstructure, enclosure, finishes, and occupancy). Any key milestones and phasing relationships should be illustrated. Your summary schedule should be approximately 25-30 activities. Show activity names, durations, and start and completion dates in the left margin of the schedule. Make sure the schedule is easy to read and follow. Briefly describe in your presentation the key elements of the foundation, structural and finish sequences.

#### (10) ***B. Building Systems Summary (1-2 slides)***

Highlight the building systems used on your project – be sure to cover all of the elements appropriate from the “Building Systems Summary” form at the back of this assignment describing the key aspects of the design and construction for your project. Include any goals set by the project team to achieve LEED Certification, or any unique building project features.

#### (10) ***C. Project Cost Evaluation (1-slide)***

Evaluate the costs of the building systems by performing the following tasks:

- Report the actual building Construction Cost (CC) and CC /SF. Do not include land costs, site work, permitting, etc.
- Report the Total project Costs (TC) and TC cost / SF.
- Report major Building Systems Costs and Cost /SF (May place emphasis on option). This should include as a minimum the mechanical system, electrical system, and structural system.
- Produce a Square Foot estimate for your building using R.S. Means data, and (save the details from the analysis, you will need to attach a reference from the source you use for cost information in Tech Report II). Briefly highlight in your presentation the assumptions and any revisions to the standard square foot data.
- Briefly compare and discuss the differences between your estimates and the actual project costs.

**(10) D. Existing Conditions Site Plans (See checklist) & Local conditions (1-slide)**

Obtain the site plan(s) used by the contractor and develop a site layout drawing for the temporary facilities (general conditions items) on your project. Develop **your own** version of the site plan on CAD, PowerPoint, or Revit. Show locations of parking, access roads, and hydrants, utility locations, neighboring buildings (with height of structure), traffic and pedestrian patterns. (3D/4D site plans are typically very effective visualization tools, and are encouraged, but are not required.) Your site plan should look professional.

List any preferred methods of construction in the region, availability for construction parking, available recycling and tipping fees, and type of soil/subsurface water condition.

**(10) F. Client Information (1-slide)**

Describe the owner of the project. Why are they building this facility e.g. mission critical, growth, relocation, etc.? What are the cost, quality, schedule and safety expectations for the project? Identify examples of their actions to support your descriptions. What sequencing issues are of interest to the owner? Are there any joint, dual, or phased occupancy requirements? What are the keys to completing the project to the owner's satisfaction?

**(10) G. Project Delivery System (1-slide)**

Define briefly how the project is being delivered, e.g., design-bid-build, design-build, construction management, etc, and why that approach was chosen. Produce an organizational chart for your project that demonstrates the following for each major project player (Owner, Architect, Engineers, Contractors, and **Specialty Contractors related to your option**, e.g. steel erector, HVAC contractor, electrical contractor etc:

- Role in project
- Name of Firm
- Key Contact (if available)

Your chart should also include the types of contracts held between different players and any other interesting relationships, e.g. joint ventures, LLC, or key communication lines. You can place the contract types on the lines within the organization chart. Include a paragraph describing in detail the essence of the contractual agreements between parties, with an emphasis on the construction contract terms. How was a contractor selected? What bonds and insurance are required? Assess the appropriateness of the contract types and delivery systems for the project.

**(10) H. Staffing Plan (1-slide)**

Develop an organizational chart describing how the CM/GC staff is assigned to the job. Briefly describe the structure of the project management and supervision staff.

## **Technical Assignment 2: Cost and Schedule Analysis**

This section of your thesis will allow you to analyze the key features of the project that affect project execution. You will determine important schedule attributes and the costs of a key building system. This will be submitted on the date noted in the schedule on page one as a printed technical report. The

### **(10) *Executive Summary / Table of Contents***

#### **(20) *A. Detailed Project Schedule***

Develop a more detailed construction schedule for your project by trade. This is the schedule you will use for your cost loading. Your schedule should reflect how the project was built, including phasing and structural sequences, and make distinctions between MEP rough-in, distribution, and finishes. Each project will be different; however do not exceed 200 activities.

#### **(20) *B. Detailed Structural Systems Estimate & Assemblies MEP Estimates***

Develop a detailed estimate for a typical bay (or logical module) of the system you have chosen for your estimating analysis. Prepare Assemblies cost estimates for the MEP systems employed on your project. You may choose an alternate system as the detailed estimate, otherwise you should estimate the cost of the scope of work for the superstructure. Complete this calculation by providing the major cost areas, eg. cubic yards of concrete and/or tons and number of pieces of steel, etc. Include foundations, slab on grade, elevated decks, columns, roof slabs, and flatwork. (Show calculations) Using a Square foot method, extrapolate this section to provide an estimate of the labor, material, and equipment costs for the entire system.

If you select an alternative system which is approved by your faculty consultant, provide effective overall ratios for evaluating your detailed estimate, e.g., \$/sf for exterior enclosures, \$/sf for electrical, etc. After developing the costs, compare back to your Square Foot estimate / Cost Model for the overall project – how do your assembly and detailed estimates compare to the system breakdowns from the first estimate? Identify the major differences in the assumptions and elements for how your more detailed estimate represents the building design, resources, and constraints.

#### **(15) *C. Site Layout Planning***

Using the existing conditions plan created in Tech I, develop scale site plans for each critical phase of construction e.g. excavation, superstructure, or finish phase of the project (minimum of 3). Show locations of ramps, fences, temporary facilities, cranes, hoists, etc. Provide descriptions of the key features of the site layout, and critique the layout used by the contractor. Submit each site plan on 11x17 (min) sized paper and be sure to specifically reference the plans and changes in the descriptions.

#### **(10) *D. General Conditions Estimate***

Develop a General Conditions Estimate for the project. Include all project and staffing costs. Do not include home office overhead. Include monthly fees and unit costs so you can reflect the impact of schedule changes on general conditions costs. Be sure to address temporary utilities. Keep in mind that any schedule savings you propose will require a calculation in G.C. savings. Compare this with the staffing plan, and if possible the actual general conditions costs from the project – what did you identify that was not used or carried in the general conditions in terms of resources and temporary structures, what varied for staffing?

#### **(10) *E. Constructability Challenges***

Describe and include drawings / sketches of three unique and/or challenging constructability issues on the project. How did the actual site team overcome these challenges? Discuss these challenges with your project team.

- (15) **F. Leading Industry Practice Evaluation - select one** (you may propose another area but must have the area and scope approved by your advisor in advance)

***Building Information Modeling Use Evaluation***

Develop the BIM use list and Level 1 Process Map how BIM should have been used on your project. Summarize the reasons you targeted the BIM uses you suggest and the process proposed. Compare this with the actual BIM implementation on the project, including whether models were transferred from design to construction, and identify any plans related to use for turnover to the owner. Provide a critical evaluation of both the appropriateness of the BIM uses and the process for implementation as compared to your suggested uses and process.

***LEED Evaluation***

Develop a LEED strategy for your project using the most up to date LEED Point System based on the Penn State approach. Briefly summarize the results and analyze the appropriateness of each point category. Compare this with the actual LEED approach on the project. Provide an overall critical evaluation – is your project pursuing the appropriate level of certification in order to meet the client's needs and project goals?

### **Technical Assignment 3: Alternative Methods Analysis**

This section of your investigation will allow you to begin to identify areas of the project that are good candidates for research, alternative methods, value engineering, and schedule compression. These will form the basis for your final thesis proposal.

**(5)     *Executive Summary / Table of Contents***

**(30)    Project Manager Interview:**

**Schedule Acceleration Scenarios (15)**

Describe the critical path of the project schedule. What are the biggest risks to the project completion date? What are key areas that have potential to accelerate the schedule if needed? What would be the costs and techniques?

**Value Engineering Topics (15)**

Describe key areas of value engineering that were implemented on the project. How did these correlate / detract from the goals of the owner? What ideas for value engineering were considered but not implemented?

**(15)    Critical Industry Issues**

Briefly summarize the results of the sessions that you attended during the PACE Roundtable Meeting. What surprised you about the discussion at this meeting? What issues might affect or be applied on your project? Who are the key contacts that you met that might be able to advise you in your area of interest?

**(10)    Feedback from Industry Roundtable**

In addition to the research topic ideas generated at the Roundtable, there will be a dedicated session at the end of the day in which you and an industry member will delve into your building, the sessions you attended, and the opportunities. The form used to take notes will be collected, and in addition you need to briefly summarize the feedback and ideas you received from these discussions.

***Presentation & Summary of options***

**(20)    Problem Identification and Technical Analysis options (max of 3 pages) – due at the start of presentations:**

Identify 5-7 problematic features of your thesis project that could be pursued through a detailed analysis of technical building systems and construction methods. Conclude with four leading options for your spring proposal and briefly describe how you would complete your analysis. What types of design and construction analyses will be required? Also, identify the breadth opportunities of the preferred options would offer.

**(20)    Proposal Presentation**

In a 5 minute presentation, summarize your project and the analysis areas you intend to pursue for your spring proposal. You may use a maximum of 5 slides, one to introduce your project, and four to explain the analyses you would like to pursue (one slide per topic). Bring a print copy of your slides for each of the thesis advisors (4 copies). You will also be evaluated on the quality of the visual communication of the slides and the clarity and professionalism of your presentation.

## Final Proposal for Spring Thesis Project

Your final thesis proposal should include the following items:

- Cover page
- Executive summary
- Table of Contents
- Analysis descriptions (four (4) analyses topics minimum)
- Conclusions
- Appendix 1 – Breadth Studies

### Technical Analysis Descriptions:

You should have **at least 4 analyses topics** identified for your proposal. For each analysis topic, clearly define the problem (or opportunity) supported by: 1) background research performed, 2) the potential solution(s), 3) the steps that you will perform to achieve your technical analysis / research, and your expected outcome. It is important that you perform a preliminary analysis to analyze the viability of your potential solutions prior to completing your proposal.

### Critical Issues Research Methods

One of your analysis topics will be a *critical industry issue*. Identify a critical issue you wish to pursue through your research based on your experience, interests, and experience at the PACE Roundtable meeting. Include a **problem statement** that identifies the challenges facing the industry in this topic. State the **goal of your research**, e.g. who will be the audience, who will benefit, etc. State specific measurable research steps, such as literature review and expert interviews, and summarize results. Describe the sources of outside information you will require. Provide a draft of the data collection tool that you will use (survey questions, interview format).

### Demonstration Breadth – Embedded Requirements

The demonstration of breadth in Architectural Engineering should be accomplished in one or more of your 4 analyses topics. You are required to illustrate your breadth skills in at least two option areas outside of construction, e.g., structural, lighting, electrical, mechanical, or acoustics. This can be accomplished by identifying an analysis which requires a more detailed breadth study to successfully complete the analysis. Then, you should allot a larger percentage for either (1) Value Engineering Analysis **or** (2) Constructability Review, whichever is most appropriate for your breadth study. You will also need to submit a separate one page document which clearly defines your breadth areas as an appendix to your proposal. This document will also be submitted separately for review by Prof. Parfitt and Prof. Holland. For ideas regarding breadth analyses, please reference the eStudio website in the 'Breadth Proposal Ideas section (available from the home page). **Note:** *Breadth proposals will be rejected if they do not include sufficient construction content and motivation. Breadth requirements are expected to be achieved through well-round analysis of the project through the lens of the construction industry*

### Proposal Requirements

Submit a proposal that describes your intentions for your Thesis Investigation to be conducted in the Spring Semester. Include the specific systems and methods you will use to perform each analysis, and your initial ideas for cost, schedule, and process improvements. Demonstrate the source of your ideas e.g. PACE, AE 473, classmates, project contacts, etc. Clearly identify the breadth analyses that you will do within the analysis areas. Remember that these should not be a separate, individual analysis, but instead, embedded into one of the construction analysis areas. The proposal should be written as a professional document and include an executive summary and table of contents.

### Core Thesis Investigation Areas

You should plan to distribute your effort among different analyses you propose for the spring. Note that you need to perform at least 2 breadth studies. These should be integrated into the analysis areas.

You will be required to complete a more detailed analysis of your project and propose changes to the existing building process and systems you are studying. Your proposal should be organized by analyses that you plan to perform. You should have 3 or 4 analyses. Within each analysis, the following core areas of investigation can be addressed. A detailed description of these areas is included in the following section.

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

Note that not every analysis area will cover every core area, but you should consider if and how you address each of the areas within your analyses. The four areas are further defined below:

1. *Critical Issues Research*– Investigate a current issue facing the construction industry. Some examples include risk analysis, contracting strategies, new technology, or new green building systems. How will you address this issue on your project? Perform independent research which should include a literature review, along with independent research such as surveys, interviews, experiments, or other research methods.
2. *Value Engineering Analysis* – Assess the goals/priorities of the owner and the design scheme. Identify potential areas to save costs and/or schedule time that will not infringe upon the intent of the design. Provide three value engineering ideas including estimates of cost savings and impact on schedule time. Provide suggestions to ADD value to the building, not simply reduce cost through lower quality.
3. *Constructability Review* – Review the structural system (or other appropriate system) in terms of constructability, e.g. steel staging, concrete formwork, precast / post-tensioned members. Evaluate the integration of the structural system and mechanical systems, e.g., plenum height, riser locations, and position of mechanical floors. Determine potential areas for prefabrication for structural elements, facade and mechanical systems. Identify alternative design schemes that would ease coordination problems.
4. *Schedule Reduction / Acceleration / Re-sequencing Proposal* – Determine the costs of reducing the project schedule by 10-15% of its planned duration, or identify a means to re-sequence to save time/resources /field implementation challenges. Choose an area of the project that has presented challenges and frustrations to the contractor. Present a detailed plan to achieve this time or other resource savings, and a detailed estimate of the costs. Consider the need to implement this plan late in the project as a method to get back on schedule in the event of unforeseen delays.

### ***Overall Breakdown:***

Suggest a weighting breakdown of how much of your spring grade will consist of each of the selected analyses areas. No area can exceed 40%, and no area can be less than 15% of your final grade. The weighting of breadths will be included in the related depth analysis – so make sure to weight each analysis in accordance with the level of effort involved and your emphasis in the spring.