Construction Option Thesis Requirements:	**Fall 2016**
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.

Course Objectives:

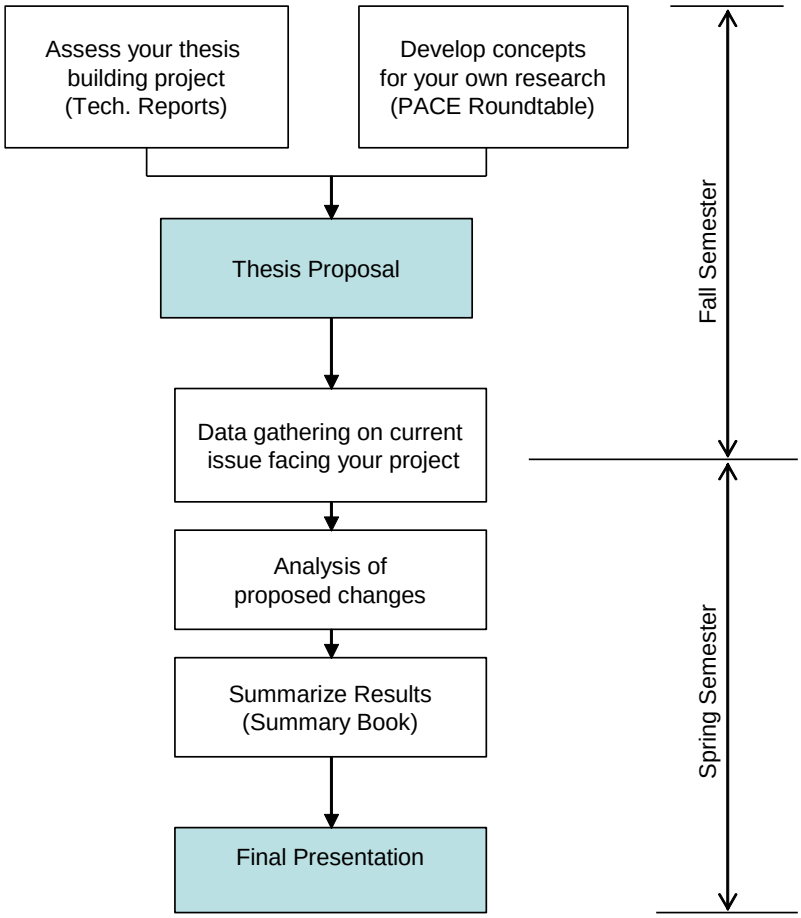
- Gain a working understanding of the technical systems and construction challenges on your thesis building to identify potential improvements
- Gather data through industry sources on key relevant issues facing the building industry and your project.
- Develop and produce a concise, professional oral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

Key Dates / Grading Percentage for Technical Assignments:

15%	**Tech 1**: Construction Project Management	September 16
20%	**Tech 2**: Cost and Schedule Analysis	October 17
	PACE *Roundtable Meeting (Attendance required)*	*Oct 27-28*
20%	**Tech 3**: Methods Analysis	November 9
	Proposal Presentations	*Nov 28*
20%	**Final Thesis Proposal**	December 9
25%	**Project Management**	Provided by Prof. Bowers

Grading
Electronic copies of each submission will be due to your advisor by the indicated deadlines. Electronic copies of each report are to be submitted via Turnitin.com in addition to their submission to your advisor. You are also required to electronically post your report per the thesis requirements. Due dates are fixed and final.

Thesis Process



I. 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.

(40) Presentation

Prepare a 6-8 minute presentation with a maximum of 8 PowerPoint (or similar) slides. Each slide should focus on presenting the information visually. 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 capturing the narrative that you will use to highlight the critical information, constraints, or findings from each area you study.

A. Project Schedule Summary (1 slide)

Produce a summary schedule of your project. Include the design phase, and procurement of construction services timelines. 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 30 activities. Briefly describe in your presentation the key elements of the construction sequencing and how it relates to the building systems, e.g. foundation, structural and finish sequences.

B. Building Systems Summary (1-2 slides)

Highlight the building systems used on your project – be sure to cover the critical 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, such as LEED Certification, or unique building project features that influence system design and construction, e.g. green roof.

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. Save the details from the analysis, you will need to attach a reference from the source you use for cost information in future work. Briefly highlight in your presentation the distinguishing features - which system costs are noticeably high or low, and why?!
- Briefly *compare and discuss the differences* between your estimates and the actual project costs.

D. Site Plan of Existing 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 using CAD, Revit, or appropriate similar tool (to clarify Photoshop & PowerPoint are not appropriate tools). 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.

Discuss any preferred methods of construction ***in the region, availability of space (e.g.*** construction parking***, material laydown, pre-assembly activities, etc.)***.

F. Client Information (1-slide)

Describe the owner of the project. Briefly summarize their drivers and expectations that relate to how the facility was financed, designed and delivered. Why are they building this facility e.g. mission critical, growth, relocation, other? What are the cost, quality, schedule and safety expectations for the project? 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? Be sure to identify examples of their actions to support your descriptions, such as schedule phasing requirements or sustainability certification incentives.

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 of critical importance**, 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.

H. Staffing Plan (1-slide)

Develop an organizational chart describing how staff is for the CM/GC (or appropriate key party with permission from your advisor) are assigned to the job. Briefly describe the structure and roles/responsibilities of the project management and field supervision staff.

(60) Project Executive Summary

Prepare a maximum four page summary (plus appendices) of the key project details, findings from the above analyses, system details, and overall project characteristics of the project. This should include an executive summary of the project and the outcomes of your analyses. The content should include critical information for all of the areas noted from your presentation, including the project organization, contractual arrangements, owner goals and expectations, including construction schedule, and budget. Highlight any distinguishing requirements, e.g., the project is targeting a new sustainability rating system, any unusual techniques or methods used in construction, alternative delivery methods, or emphasis on information technology solutions. Your document should be written as a professional technical report. You should include, at a minimum, two images or tables to more easily present critical information about your project. The appendix to your report should include the schedule (print at a readable scale), square foot estimate w/ appropriate notes, and the full scale site plan for your project.

II. Technical Assignment 2: Production Analysis

This portion of your Fall Thesis is intended to allow you to focus on key features of the field production planning and resource use for key systems within your project. This will be submitted on the date noted in the schedule on page one as an electronic technical report.

(10) Executive Summary / Table of Contents

Prepare a, maximum, one-page executive summary of the key ***findings*** from this assignment. This should be a stand-alone summary that highlights the analyses performed and the ***outcomes*** of the analyses. The content should include highlights from all of the areas noted below, including key aspects and critical analysis findings regarding system construction means and methods, schedule, costs and resource use, as well as the logistics. In addition, be sure to highlight key feedback from the field supervisor interview that aligns or contradicts your analyses.

(40) Production Plan

Develop the detailed schedule, labor projections, logistical details for the site, and the resource needs for a critical engineered system within your project. Examples of appropriate systems include: Foundation and building structure, building enclosure (façade and roofing), mechanical system, or electrical system.

- System construction means and methods: summarize the system details for the chosen analysis, what are the assemblies and components that are necessary, what means and methods were chosen, what design standards define performance and quality outcomes, what key resources, equipment, and workforce are needed to successfully install the system.
- Production schedule: using Primavera, develop a detailed, manpower loaded, production schedule for the targeted system. Be sure to build upon the overall project schedule to define critical predecessor activities and milestones, you will likely need to add detail to other systems to create the appropriate logic for the focused system you are analyzing. Demonstrate the flow of work through the project based upon the means and methods, logistics, crew size(s) and key milestones for successor activities. Produce the labor curve for this scope of work. Include a narrative that explains the flow of work and production drivers.
- Detailed costs: develop, using Timberline, the detailed cost estimate of the system you have chosen. Be sure to adjust the labor needs and resources to match the planned implementation and means & methods expected for the project. Be sure to provide a brief explanation of the estimate, key assumptions, and adjustments that were made.
- Site plans and logistics: refine the already developed site logistics plans for each stage of the production sequence (minimum of three). Visually highlight key changes and workflow considerations for the selected system(s). Be sure to represent the flow of work between areas of the facility, direction of the workforce, locations of materials and equipment, locations and movement of temporary systems (e.g. scaffolding) and access for deliveries, materials, and critical equipment and workforce needs. Be sure to include a separate narrative explanation that describes the key features at each stage, as well as the transitions between them.

(30) Production Analysis

Based upon the production plan that you presented, provide a ***critical analysis*** of the approach, logistics, schedule, resource use, and costs included in the plan:

- Production: How efficient / effective is the schedule given the crews, resources, site constraints? How well does it align with, support, or constrain other concurrent construction tasks or trades? Provide evidence of your claims based upon the plan details you presented.
- Cost analysis: How well does your cost estimate align with the original square foot budget you assembled and the actual construction costs for your system? Define key assumptions and provide reasons for the noted differences.
- Logistical analysis: Analyze the use of space on the project and identify alternative options for means and methods, material movement, temporary systems, equipment selection or location, and

logistical flow of trade(s) through the site that could improve site use for your chosen system or the predecessor/concurrent/successor trades on the project.

(20) Field supervisor interview

Schedule a **call** or **face-to-face interview** with the superintendent, (or foreman), responsible for overseeing the installation of your chosen system. During the interview, document their feedback on the constructability of the system design, the site logistics, means and methods, as well as means for improving production through improved site use or other changes to the plan. Expand the discussion, as appropriate, to capture other challenges that affected the schedule and constructability of the project – what site challenges, procurement issues, or delays impacted the project? Include the typed transcript summarizing the questions and answers in the appendix.

Schedule Acceleration Scenarios (10)

Describe how the system schedule relates to 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 re-sequence or accelerate this system, **excluding increased manpower or shifts**? What resources, costs and techniques would be required to accomplish these alternative options?

Constructability and logistical Challenges (10)

Describe unique and/or challenging constructability issues for your selected system, (include drawings/sketches/models). How did the actual site team overcome these challenges? Discuss these challenges with the superintendent to understand how they would affect the design materials choices, means and methods of construction, connection details, sequencing, equipment or resources selection, and any additional system decisions or constraints.

III. Technical Assignment 3: Exploring project challenges and opportunities

(5) Executive Summary / Table of Contents

Prepare a, maximum, one-page summary of the key findings from this assignment. This should be a stand-alone summary that highlights the analyses performed and the ***outcomes*** of the analyses. The content should include highlights from all of the areas noted below.

(20) Project Manager Interview:

Schedule a **call** or **face-to-face interview** with the project manager or executive responsible for overseeing your project. During the interview, document their feedback on the overall project challenges for the schedule, client requirements, design management, value engineering, and delivery method. Include the typed transcript summarizing the questions and answer in the appendix.

Project Management Services (10)

Describe the project management services, such as preconstruction services, sustainability evaluation, and procurement, provided to the client. What are the biggest challenges or constraints for the client, such as financing, user engagement, phasing, or quality? What are key areas that have potential to better fit the project approach or management services to the clients' needs? What would be the costs and methods for implementing these?

Value Engineering Topics (10)

Describe key areas of value engineering that were implemented on the project. How did these improve or detract from the goals of the owner? What ideas for value engineering were considered but not implemented? Why? What systems were not a focus of VE but could offer opportunities based on the current status?

(15) Critical Industry Issues - PACE

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? In particular, what topic or area offers an interesting area for further research in the spring semester?

(10) Feedback from PACE 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 (distributed at PACE) you use to take notes will be collected, and in addition there is space for you to briefly summarize the feedback and ideas you received from these discussions.

(30) Leading Industry Practice Evaluation

Building Information Modeling Use Evaluation (15)

Develop the BIM use list and Process Map showing 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 by the project team and the process for implementation as compared to your suggested uses and process.

Sustainability Implementation (15)

Develop a Sustainability strategy for your project using the most up to date LEED Point System based on the Penn State approach (you may use alternate sustainability systems with approval of your advisor, such as Living Building Challenge, Green Globes, or BREEAM). Briefly summarize the results and analyze the appropriateness of each category based upon your project goals. Compare this with the actual LEED approach on the project. Provide an overall critical evaluation – is your project pursuing the appropriate level of sustainability in order to meet the client's needs and project goals?

(20) Presentation & Summary of options

Identify 5-7 problematic features or areas of your thesis project that could be pursued through a detailed analysis of technical building systems and construction methods and discuss them with your advisor. In a 5 minute presentation, summarize your project and present the four leading options for your spring proposal the analysis areas you intend to pursue. 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 with the additional topics as back-up for the discussion). Bring a print copy of your slides for each of the thesis advisors (2 copies). You will also be evaluated on the quality of the visual communication of the slides and the clarity and professionalism of your presentation, so be sure to use clear visuals that show the constructability impact, lifecycle cost, schedule or logistical challenge, or picture to convey your research idea. Be sure to discuss ***how*** you would pursue the analysis, and identify which topics offer breadth analysis opportunities.

IV. 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 process that you will use to achieve your technical analysis / research, and your expected outcome. Your process should lay out each of the steps through the spring semester, as well as how you will carry out each step, what analytical tools or procedures you will use, what investigation you will need to conduct on the selected systems, and how you will compare your findings to the existing design and construction process. It is important that you perform a preliminary analysis to identify 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 and who will benefit.

Some examples areas 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. State specific measurable research steps, such as literature review or expert interviews, and summarize the expected analysis and results. Describe the sources of outside information you will require (e.g. access to an email list to distribute a survey, experts in ___ for interviews). Provide a draft of the data collection tool that you will use (survey questions, interview format).

Construction Depth

The core of your proposal will be used identifying your construction depth analyses and the process for carrying out your investigations. 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 need to identify three construction depth topics, in addition to your critical industry research, making it four topics in total you identify.

Construction depth topics should be specific to your building project, and can range from Value Engineering options, to improved constructability, to re-sequencing or accelerating the schedule. Identify the options relative to the targeted problem. Provide an evaluation of the options (whether better lifecycle value, improved productivity, or shortened critical path, among other indicators of success). Provide the plan for how you will conduct the appropriate construction analysis, hopefully building upon the baseline details demonstrated in Tech II.

Demonstration Breadth – Embedded Requirements

The demonstration of breadth in Architectural Engineering should be accomplished in one or more of your construction depth analyses topics. These should be **integrated** into the analysis areas. 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. 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. Bowers. 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.