Thesis Instructions

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Part I. Thesis project approval, submission, and grading guidelines

1.1 Thesis project approval and submission

1.1.1 Project approval

- Each thesis student is required to find a project to analyze for their thesis project. Projects will align with the following characteristics:
    - A building construction project, preferably a stand-alone structure with a gross square footage of no less than 9,000 sf and up to 25,000 sf, and the project cost (approximate from the architect or contractor) between $1M and $5M. At least ¾ of the project square footage should be heated and cooled and include finished partitions, floors, ceilings, doors, etc. (i.e. not a warehouse, storage space, tenant shell, or hangar). "Big-box" projects (e.g. Wal-Mart), Pharmacies (e.g. Walgreens), or other similar "open" floor plans are not acceptable.
    - A project of non-prototype design (i.e. not a building that is replicated from site to site with a common building design). Pre-engineered structural systems are not acceptable. Pre-engineered wood or metal roof trusses are acceptable.
    - A project with substantially completed construction documents, including architectural, structural, mechanical, electrical, plumbing, and civil drawings, and accompanying specifications as a separate manual (specifications on the plans are not acceptable).
    - A project with substantive sitework, which has required the development of a geotechnical report must be included in the submission for approval.
- Review the *Thesis Submission Instructions* found on the Building Science website. The approval form and the process for submitting are detailed at the link provided on the website.
- Only one unique project will be approved for each student. A student may apply for approval of a project up to one full academic semester before their Thesis semester.
- An approval form signed by the thesis instructor is required prior to starting any thesis work. The signed approval form must be included with the final thesis submission.

1.1.2 Thesis submission guidelines

- Thesis submission will occur in three separate parts:
  - Project plan
  - Full thesis submission
  - Student presentation
- Project Plan
  - The purpose of the project plan submission is to provide students with feedback on their progress prior to their full thesis submission. The project plan will be submitted via Canvas on a day and time outlined by the thesis instructor. Detailed project plan submission requirements are outlined further in section A of this document.
- Final thesis submission

  The final thesis submission encompasses all work required of the thesis student. The final thesis will be submitted on Canvas or as indicated otherwise by the thesis instructor and will include (1) a bookmarked PDF file, (2) native files for specific thesis items, and (3) a PDF copy of the signed thesis approval form. Detailed final thesis submission requirements are outlined further in sections B-K of this document. Only final thesis submissions that include all the items listed in this document will be accepted.

  - The bookmarked PDF file is to be broken down into the following 11 sections. Each section should be all-inclusive of the items described in this document, unless noted otherwise. Specifically, everything in your thesis PDF file should include backup documentation if it can be included in the PDF file. For instance, labor burden calculations for field personnel that are calculated using a Microsoft Excel spreadsheet, should be included in the PDF. Take time to consider the presentation of such content in the PDF file – you may need to include a short description of the documentation that you are including. A cover page and Table of Contents will precede the items listed below.

    1. Project Plan
       - Include a copy of the full Project Plan. This should be un-edited from the original Project Plan submission and include all faculty feedback if available.
    2. BIM Summary
       - Include five to ten "model shots" that represent the overall scope of the project, including description of what the grading professor should interpret about the project from each model shot.
    3. Structural Analysis
    4. Financial Analysis
    5. Estimate
       - Include only the "recap sheet" of the developed estimate, and alternate(s).
    6. Schedule

        - Include the complete CPM schedule (scaled to Arch D 24x36 paper size, at a minimum).
    7. Safety
    8. Project Documents
    9. Payment and Cash Flow
    10. Unforeseen Incident
        - Include a copy of the "Unforeseen Incident" document that was issued to you by the thesis instructor.
    11. Student Selected Work
  - Submission files also must include native format copies of the following items. Additional native format documents may be requested by the grading professor.
    1. Project parametric Building Information Model –BIM (e.g., .rvt, .skp)
    2. Project estimate (e.g., .xlsx, .ost)
        - Quantities in the Microsoft Excel estimate file should be hyperlinked directly to all quantity takeoff summaries to serve as an audit trail.
    3. Project schedule (e.g., .xer, .mpp)
  - The complete set of project documents (e.g., plans, specifications, geotechnical report) must be organized and included.
  - The grading professor may, at their discretion, request that properly formatted hard copies of certain thesis components be provided after the thesis submission, but prior to the student presentation.

- Student presentation
  - The presentation component of the thesis provides thesis students with the opportunity to engage with the grading professor through describing their analysis of the thesis project and showcasing their oral and written communication skills in a professional manner. Students are to plan for a 30-minute presentation and are required to <u>summarize</u> each thesis component during their presentation.
  - The following items, at a minimum, are to be covered in the student presentation. It is highly suggested that students go above and beyond these minimum requirements to fully showcase their understanding of their thesis projects.
    1. An overall explanation of the mock company developed by the student, and the projected financial position of the company.
    2. An overall explanation of the project, including site location, and descriptions of the major structural, architectural, and building system components.
    3. Existing site characteristics, along with earthwork (cut/fill, topsoil stripping quantity and stockpile location, erosion control, etc.) and site utility construction to be completed.
    4. Proposed sequencing of the work, and overall project schedule. Project cash flow should also be discussed.

5. Estimated costs for the project, including self-performed work, subcontracted work, general conditions, corporate overhead, and profit.
6. Site-specific safety considerations and mitigation strategies.
7. The student's interpretation and reaction to the "unforeseen incident."

- It is highly suggested that students leverage technology (e.g., BIM software(s), Microsoft PowerPoint, other software programs) and the deliverables created during the thesis development to visually represent and emphasize their analysis of the project.
- The audience for the presentation is the grading professor, meaning that the student does not need to gear their presentation towards a fictional project executive, project owner, etc.
- Presentations will be completed as part of the thesis grading process, described further in Part II of this document, and will be scheduled on a day and time convenient for both the thesis student and the grading professor after the final thesis submission.

1.2 Grading instructions and rubric

1.2.1 Thesis grading

- The project plan will be graded by an individual professor approximately four to five weeks into the semester for spring and fall graduates, and three weeks into the semester for summer graduates. Professors will be assigned by the thesis instructor. Project plan grades are part of the overall thesis grade.
- Final thesis submissions will be graded by an individual professor at the end of the thesis term. Professors will be chosen at random by each student through a name drawing on the day and time of the thesis submission.
- Individual professors will grade the thesis submissions using the component descriptions outlined in Part II of this document.
- Each thesis component will be given a grade mark (with associated numerical value) based on the following scale. The grading professor may interpolate between the point values listed below at their discretion.
- A thesis that is submitted after the designated time (appearing as a late submission in Canvas) but prior to one hour after the due time in Canvas will be penalized by a one letter grade reduction. A thesis submitted beyond one hour after the due time in Canvas will be scored as an "F".
- All parts of the thesis submission must be reasonably completed and included in the submission. The omission of portions of the thesis submission will result in a grade assessed no higher than a “D” and possibly an “F”.
- A thesis submission scored as a “D” or an “F” by the grading professor will undergo further examination by additional faculty members and/or the BSCI School Head to confirm the grade. A thesis submission assessed as an “F” is considered failing the course.

Grade Mark	Point Value	Grade Description
A+	100	Exemplary work that is complete, accurate, organized, and compelling with no errors. Comprehensively meets all criteria for the component as articulated in the thesis instructions.
A	90	Compelling work, demonstrating clear understanding of the work, and/or mastery of the task. Only a few minor errors and/or omissions are present, and with most components firmly correlated to others.
B	80	Solid submission, demonstrating good understanding of the component or task. Reasonably organized, but with errors, omissions, and/or questionable approaches based on criteria in the thesis instructions. Some components may not correlate relevantly to others.
C	70	Minimum requirements are generally met, but with minor/major errors and/or omissions. Work is marginally organized, and/or some decisions/strategies questionable. Multiple components may not relevantly correlate to others.
D	60	As a component, is present, however with multiple minor and/or major errors or omissions. Poorly organized and difficult to follow/audit. Components may be frequently disjointed and not properly correlated to others.
F	<60	As a component, was attempted but with multiple significant and egregious errors and/or omissions. Delivery, organization, and/or evidence of understanding is poor, and the student struggles to defend or rationalize the work.
-	0	Work not present in submission

Part II. Detailed thesis requirements

2.1 Thesis categories and associated weights

The thesis consists of eleven major categories, each with category having a series of components. Each category will have an associated point value, and each component will be weighted within each category. The thesis categories and individual components are described in detail in the following sections.

Category		Point Value
A.	Project Plan	10
B.	Parametric Building Information Model (BIM)	15
C.	Structural Analysis	5
D.	Financial Analysis	8
E.	Estimate	15
F.	Schedule	10
G.	Safety	5
H.	Project Documents	7
I.	Payment and Cash Flow	10
J.	Incorporation of “Unforeseen Incident” Scenario	5
K.	Student Selected Work	10
	Total	**100**

2.2 Detailed descriptions of thesis categories and components

A. Project Plan (10 points total)

Provide an initial analysis of your company and your project, including the development of your company background information, determination of project scope for both the general contractor (i.e., your company) and your subcontractors, development of an initial project management plan, and review of the architectural and structural BIM. Additionally, provide details on your proposed student selected work. With this submission, you will also need to provide copies of your plans, specifications, and geotechnical report for the grading professor to review.

Components of this category to be assessed:

A.1 – The "Company" (10% of weight)

Develop your "company" information, including (but not limited to):

- Name
- Legal structure of company
- Graphic representation of management structure, including executives, managers, office staff, and field management, including the size of your company in terms of people and revenue or sales

A.2 – Project scope analysis in written narrative format (20% of weight)

Analyze the project documents to determine the project scope and summarize your findings in a written narrative, including (but not limited to):

- Provide a summary of the project, including location, approximate gross square footage, use (school, firehouse, library, etc.), and any other pertinent information.
- Building structural system(s) identified, with major components noted and proposed construction methods (e.g., hoisting of materials, equipment necessary to complete the structural scope(s) of work) determined.
- Building facade system(s) identified, with major components noted and proposed construction methods determined.
- Building mechanical, electrical, plumbing, and fire protection systems identified, with detailed system descriptions and major components noted, and proposed construction methods determined.
- Geotechnical report analyzed. Earthwork and site utility systems identified, with major components and risks noted and proposed construction methods determined.

A.3 – General conditions analysis in a written narrative format (10% of weight)

Analyze the project documents to discern the requirements that will be the sole responsibility of the general contractor to manage and be at risk for, summarized in written narrative format, including (but not limited to):

- Permitting
- Bonding and insurance
- Schedule (i.e., number of days stated to complete the project after contract is executed)
- Liquidated damages
- Pay application

- Warranties
- Project closeout

A.4 – Contracting strategy in a written narrative format (10% of weight)

Determine your contracting strategy for the project, and summarize your findings in a written narrative, including (but not limited to):

- Specific scopes of work to be subcontracted listed by specific trade/package, not strictly by CSI division.
- Specific scopes of work to be self-performed, including how you propose to staff the project (management and tradesmen), major materials to be procured, and what major equipment is needed for that scope.
    - A minimum of one scope of work must be self-performed by your company and a brief written explanation that justifies your selection of this scope of work.
- Specific scopes of work to be paid for by the Owner but managed/coordinated by the general contractor (if applicable).
- Specific materials and/or equipment to be purchased by the general contractor but installed by a subcontractor (if applicable).

A.5 – Project management strategy in written narrative format (20% of weight)

Determine your project management strategy for the project, and summarize your findings in a written narrative, including (but not limited to):

- Site logistics strategy, including location of temporary facilities, material laydown area(s), hoisting equipment (if necessary), temporary roads, site security measures (if necessary), and worker parking areas, shown in an overlay on the civil/site plan. Multiple logistics plans may be required to articulate changes in strategy as the project progresses. A preliminary sketch highlighting the main components of your site logistics plan should accompany this description.
- Preliminary project schedule, including all major project components. This is to be included in a Gantt chart format, consist of 15-20 activities, and be accompanied with a brief explanation of your schedule development rationale.
- Detailed explanation of how you would manage sequencing of subcontractors throughout the project.
- A listing of all long-lead items that must be incorporated into the project schedule if the project is to be completed without interruption.
- A listing of all potential site-specific safety risks.

A.6 – Parametric Building Information Model (BIM) (20% of weight)

Provide a complete structural and architectural model of your BIM including (but not limited to):

- All structural components
- Skin/substrate
- Interior partitions, ceilings, door frames, doors

A.7 – Student selected work in written narrative format (10% of weight)

Provide a written narrative (300 – 500 words) describing your proposed student selected work, including (but not limited to):

- What work items student proposes to complete

- How work items will be completed
- Anticipated completion time (in hours) for each work item
- Other

B. Parametric Building Information Modeling (BIM) (15 points total)

Building Information Models play a key role in the completion of the BSCI thesis. Students are required to model the structural components, architectural components and MEP systems of the project. The model will be used to demonstrate student's ability to complete the estimate, coordination, site safety, site logistics, structural analysis etc. Students should acquaint themselves with the buildingSMART Level of Development (LOD) descriptions. These are available at http://bimforum.org/lod/

The following elements are required to be modeled:

Item Description	**LOD**					
	100	**200**	**300**	**350**	**400**	**500**
Structure						
Isolated foundations				x		
Piles			x			
Wall foundations				x		
Load bearing walls (concrete, wood & masonry)			x			
Columns (steel, concrete, wood & composite)			x			
Beams (steel (incl. OWSJ), concrete, wood & composite)			x			
Lintels (steel, concrete & wood)			x			
Rebar (representative where applicable, ex: Isolated foundation)			x			
Seismic and wind braces			x			
Stairs (incl. handrails)			x			
Roof trusses (wood & steel)			x			
Temporary structures (ex: wall bracing, slab formwork)					x	
Architecture						
Exterior skin (incl. curtain walls)			x			
Interior partition walls			x			
Exterior & interior doors		x				
Mechanical						
All ducts and duct insulation		x				
All heating & cooling equipment		x				
Electrical						
Cable trays		x				
Conduit above 1" diameter that is shown on the drawings		x				
Electrical panels and equipment (as shown on plans)		x				
Lighting fixtures		x				
Plumbing						
All pressure piping (ex. domestic water)		x				
All gravity piping (ex. drain, waste, and vent)		x				
Plumbing equipment and fixtures (as shown on plans)		x				

Students may use any commercially available software for completing the electronic requirements for the thesis. However, students are encouraged to consider software that has the highest market share for a proposed task.

<u>Components of this category to be assessed:</u>

B.1 – Structural Model (20% weight)

Develop a structural model of your building at the required LOD, including (but not limited to):

- All structural elements, including foundations, beams, columns, load bearing walls, retaining walls, braces, and roof trusses
- All openings in slabs and walls for doors, windows, skylights, ducts, and large pipes
- All structural reinforcing for concrete

B.2 – Architectural Model (20% weight)

Develop an architectural model of your building at the required LOD, including (but not limited to):

- All interior and exterior walls, skin, and partitions
- All ceilings, millwork, major finishes (may be applied in room settings), doors and windows
- All stairs, ramps, etc.

B.3 – MEP Model (15% weight)

Develop an MEP model of your building at the required LOD, including (but not limited to):

- All mechanical elements, including ductwork, duct insulation, grilles/diffusers, and equipment
- All electrical elements, including equipment, cable trays, main feeder conduit, devices and light fixtures. Exclude branch circuitry and conduit.
- All plumbing elements, including fixtures, pressure piping, drain, waste, and vent piping, and equipment

B.4 – Clash Detection (10% weight)

Perform a clash detection of the models, for the following disciplines:

- MEP vs Structure, per floor, by discipline (e.g. 1st floor structure vs. 1st floor HVAC)
- Architecture vs Structure, per floor
- Architecture vs MEP, per floor, by discipline (e.g. 2nd floor architectural vs. 2nd floor electrical)
- Document the clashes using either videos or highly annotated screen snapshots illustrating at least three significant clashes (not poor modeling clashes). Include this media in the Bookmarked PDF and the Student Presentation.

B.5 – Post Clash Remediation Recommendations (10% weight)

Propose a mitigation plan for the clashes found in the previous step, examples may include:

- HVAC distribution or equipment alternatives to avoid structural conflicts
- Alternative or improved sections to resolve conflicts between structural and architectural, at foundations, slab, and exterior framing.

- Similar substantial clashes

B.6 – Site Logistics (10% weight)

Create site logistics plans using various models and other visualization tools (eg. SketchUp) to demonstrate:

- Site access, entry/exit traffic flow, security, etc.
- Hoisting, unloading, handling equipment needs
- Material laydown
- Trash/waste strategy
- Other relevant items (e.g., office facilities, parking, sanitary facilities)
- Multiple plans will likely be required to articulate site planning at various major stages of the project

B.7 - 4D Schedule (15% weight)

Create a comprehensive 4D model including all major elements from the different BIM models to demonstrate:

- Sequence of activities based on a logical and realistic progression.
- Clear choices and strategies of structural and skin sequence.
- Phases where multiple major tasks are performed simultaneously.
- Major interior elements' installation, utilizing 'cutaway views' and/or diminished opacity of exteriors so that interior components can be seen. Include a video of the 4D model in the Student Presentation.

C. Structural Analysis (5 points total)

Students must describe how the structural system for their project carries vertical and laterals loads to the foundations. Students are to demonstrate their understanding of temporary structures necessary for the construction of the project.

Components of this category to be assessed:

C.1 - Load Tracing Description with Visuals (33% weight)

Gravity Loads

- Detailed description of the service loads the building is designed to withstand
- Use 3D parametric models to demonstrate how gravity loads get to the foundations. A written description should accompany the visual representations.
- Section-Cuts of the building from the structural model must be used to sketch vertical and lateral load paths to the foundation

Lateral Loads

- Identify the 'Main Wind Force Resisting System' (MWFRS) for the building
- Use colors/graphics or separate diagrams to distinguish the MWFRS for different wind directions
- Use 3D parametric models to demonstrate how wind loads get to the foundations. A written description should accompany the visual representations.
- Section-Cuts of the building from the structural model must be used to sketch vertical and lateral load paths to the foundation

C.2 - Temporary Construction Design (33% weight)

- A 3D model in SketchUp or Revit to accompany the temporary structure must be provided.
- If an appropriate temporary structure is not available on a student's thesis project, the student may substitute one with the approval of the thesis instructor.
- Detailed explanation of how the temporary structure impacts the construction sequence

C.3 – Presentation (33% weight)

- Students should use the structural 3D model alongside construction drawings during the thesis presentation to explain to the jury how loads are transferred to the ground.
- Students should use the 3D model of the temporary structure to show how the said item will be built and used in the field.

D. Financial Analysis (8 points total)

Define, analyze, and project your company's financial position and perspective.

<u>Components of this category to be assessed:</u>

D.1 – Organization / Entity (15% weight)

Deliver the following:

- Figures and information used to produce randomly generated 'last year's' financial statements:
  - Company data, last year: Define the construction entity
    - Brief history, background, name, and type of company, 200 words maximum
    - Last year's revenue, in dollars
  - Total annual company salaries (unburdened) that are *not* charged to general conditions
    - Representative organizational chart supporting salary expenditures
    - Description of correlation between office salary expenditures vs annual revenue, as they relate to competitive profit margins.
  - Labor burden (payroll, taxes and insurance) on the salaries described above, as a percentage
    - Show all components (FICA, SUTA, FUTA, Workman's Comp, Benefits, etc.), and describe relevance/application
      - Project location impact on SUTA, Workman's Comp, etc.
      - Voluntary benefit rationale
      - EMR impact on Workman's Comp
- Last year's Income Statement and Balance Sheet formatted appropriately. The "starting" statements will be issued to the student from the BSCI faculty based on the student-developed items for section D.1 above).

D.2 – Quantitative Analysis of Position and Performance @ Last Year/Period (20% weight)

Ratio calculation and analysis to include, but not limited to:

- Calculations of financial ratios for last year's performance and position, including (minimum): Gross Margin, Net Margin, Effective Mark-up [Gross Profit / Cost of Work], ROI, Current Ratio, Average Age of Payables and Receivables, Fixed Asset Newness
- Explanation of your analysis for *each* calculated value, and its comparison to the current market and economy

D.3 – Qualitative Analysis and Plan for the Future (25%)

Provide a written/prose narrative of your analysis (maximum 300 words):

- Comprehensive summary of quantitative analysis.
- Impact/considerations based on current trends, economy, competition, plans for growth/shrinkage, etc.
- Description of how you plan to incorporate improvements in your projected income statement for the upcoming year.

D.4 – Projection of Present/Upcoming Year (20%)

Provide a projected Income Statement reflecting your analysis and plan:

- Projections address primary items, issues, and relationships relative to gross margin and mark-up.
- Gross margin and Effective Mark-up are (or are moving toward) competitive ratios/rates
- Projections appropriately address improvement of Operating Expenses relative to Gross Profit.
- Changes reflected in the new projected Operating Expenses (variable and fixed) are reasonable and logical.

D.5 – Cross-Component Relevance (20%)

The financial analysis is comprehensively relevant and reflective of other thesis components:

- Clear articulation of how data from the projected income statement is correctly used to add corporate overhead and profit to the project estimate.
- The organizational chart and representative salaries correlate to the general conditions in the estimate (salaries, wages, equipment, etc.)
- Company revenue and salary expenditures are relevant with respect to competitive mark-up among competition.
- Projected costs of work are reflective of the scale of the company's typical self-performed work.
- Include documentation of labor burden calculations for all field personnel that are needed for your self-performed work.
- The company's Operating Expenses and projected/desired profit are accurately reflected in the cost loading of the schedule.

E. Estimate (15 points total)

Develop a complete construction estimate for your project, from the general contractor's perspective. The estimate will be developed using material quantities taken from your BIM, and other software platforms as required. Pertinent cost-related items from your project specifications should be addressed, including allowances, alternates, and unit pricing. Mechanical, electrical, low voltage, plumbing, and fire protection systems should be estimated based on a square footage price. A separate estimate is to be developed for one alternate scope of work.

Components of this category to be assessed:

E.1 – Estimate set-up (5% weight)

Estimate set up correctly, including (but not limited to):

- Appropriate location adjustment factors incorporated
- Location and contract-specific sales tax incorporated
- Pre-formatted calculations in the estimate form unaltered
- Labor burden for field and office staff documented and incorporated, as appropriate

E.2 – Quantity take-off (QTO) (20% weight)

Materials necessary to build the project calculated correctly, including (but not limited to):

- Appropriate technology leveraged to determine material quantities, such as:
  - OnScreen Takeoff
  - Earthworks
  - Stack
  - Revit
  - Microsoft Excel
  - Bluebeam
  - Other
- Quantity take-off summarized in an appropriate and easy to follow fashion, including hyperlinks from the estimate form directly to the QTO to serve as an audit trail.
- Quantities taken-off and incorporated into the estimate form using the appropriate units of measure.

E.3 – Estimate accuracy (35% weight)

Project estimated correctly, including (but not limited to):

- Entire project scope included in the estimate.
- Explicitly identify items that were not included in the model(s) but were included in the estimate.
- RSMeans line items identified to match project specific costs.
- RSMeans cost data appropriately entered into estimate form.
- Work items to be self-performed together included appropriately into the estimate form (e.g., all self-performed concrete work entered into a single (or adjoining) sections of the estimate form).
- Work items to be subcontracted together included appropriately into the estimate form (e.g., all subcontracted masonry work entered into a single (or adjoining) sections of the estimate form).

- Any allowances included in the estimate clearly documented as to their (1) assumed cost, and (2) their reasoning for inclusion in the estimate.
- Landscaping, demolition, mechanical, electrical, low voltage, plumbing, and fire protection scopes should be included in the estimate as either a lump sum or square footage cost, with a written narrative as to how pricing was determined.

E.4 – General requirements (20% weight)

General requirements necessary to (1) win the project, and (2) successfully complete the project correctly, including (but not limited to):

- Field-related general condition costs
- Permitting, insurance and bonding costs
- Corporate overhead, profit, and contingency values

E.5 – Risk factors (10% weight)

Project-specific risk factors that could potentially affect project costs identified and financially mitigated correctly, including (but not limited to):

- Schedule factors, such as cost escalation or unclassified site materials
- Site logistics factors, such as proximity to a school, or the public at large
- Safety factors
- Costs to mitigate these risks must be clear within the estimate

E.6 – Presentation (10% weight)

Project estimate presented correctly, including (but not limited to):

- Significant risks that could affect project costs identified and discussed, including mitigation strategies.
- Competition strategy discussed (i.e., how do you strategically approach this project so that you are the winning contractor).
- Project completion strategy discussed (i.e., how you would approach the construction process to ensure project success).
- Corporate overhead, profit, and contingency values included in the estimate discussed.

F. Schedule (10 points total)

Create an overall project schedule in relevant software (P6, MS Project, etc.). Include on the flash drive in native format, as well as a properly scaled and formatted PDF.

Components of this category to be assessed:

F.1 - Organization and Format (5% weight)

Employ the following standards:

- Systematically organized, and sorted by 'early start'
- Critical path identified
- Constraint/relationship lines are visible
- Cost loaded values present for each activity
- Data date is the beginning of the project
- Data columns present/visible (minimum): Activity, Duration, Total Float, Activity $ Value
- Descriptions, values and other components correct and proofread for accuracy and spelling

F.2 - Work Breakdown Structure (WBS) (20% weight)

WBS presented and organized such that:

- All components of the project scope are clearly represented in the WBS and individual activities
- Activities logically correlate to the project estimate with respect to equipment, manpower, jobsite-related general conditions, and phasing
- Activities and WBS are at a *consistent* level of detail
- Activity groupings and phases are realistic based on the scope of work to be delivered
- Procurement is properly considered for those items for which material delivery has potential impact on the project

F.3 - Overall Schedule Perspective (25% weight)

The overall schedule is compelling because:

- The overall duration is within a realistic range (and within contract limits, if applicable), based on scope, scale, location, economy, and on labor strategy in the project estimate
- The schedule and overall strategy is well presented and defended in the student's presentation
- Major phases of the project (e.g., Site, Structure, Skin, Rough-In) also have reasonable and practical duration relevant to the overall project duration
- Transitions between phases are logical based on the scope of work, type of structure and skin, and safety concerns

F.4 - Logic, Duration, Sequence (25% weight)

The project schedule reflects rational sequence and planning such that:

- All activity durations are individually realistic, and constraints/relationships are based on sound logic; the student clearly understands the scope and the schedule is well presented
- All activity 'starts' reflect all appropriate predecessors, and all activity 'finishes' transition to all appropriate 'successors'

- The critical path is logical, and well defended in the presentation
- Float for non-critical activities is realistic

F.5 - Cross-Component Relevance (15% weight)

The project schedule is comprehensively relevant and reflective of other components:

- The full scope of work is present as articulated in the Estimate
- The full scope of work is present inclusive of components in the BIM model
- The schedule accurately correlates to the jobsite-related general conditions as it relates to all variable costs (wages, rentals, etc.), site utilization, equipment, safety, and SWPPP
- All temporary measures are accounted for (underpinning, demolition, formwork, scaffolding, etc.)

F.6 – Presentation (10% weight)

Project schedule presented correctly, including (but not limited to):

- Significant risks that could affect project schedule identified and discussed, including mitigation strategies
- Project completion strategy (i.e., how you would approach the construction process to ensure project success) discussed
- Other

G. Safety (5 points total)

Develop a project-specific safety plan for the project. Do NOT include copious standard or 'boilerplate' language that could be applied to any project.

Components of this category to be assessed:

G.1 - Job Hazard Analysis (25% weight)

- Perform an initial review of the project and list the various hazards that are likely to be encountered on this project. Choose any two significant hazards and conduct a task hazard analysis and provide mitigation strategies for the same. Include visual descriptions.
- Clearly indicate how safety risks evolve through the duration of the project.

G.2 – Hazardous Communication Program (25% weight)

- Use the 3D models created to show if any temporary barriers, belt lines or signage can be used to manage safety on site.
- Provide at least one example of how the communication process will work to inform and protect employees from a specific hazard your project during construction.
- Describe your accident prevention/rescue plan for one activity/hazard that will be encountered on this project (suspension trauma during steel/precast erection, confined space rescue plan, excavation cave-in, etc.) Elaborate on the preparations you have made in case of an accident.

G.3 – Presentation (25% weight)

- Students will use the parametric model as context to explain major safety risks, and the proposed methods to mitigate.
- Describe how safety measures are accounted for in estimate and schedule

G.4 – Site Specific Safety Program (25% weight)

- Create a site-specific safety orientation of the project for new subcontractors or workers visiting the site for the first time, during the structural system installation.

H. Project Documents (7 points total)

Develop project documentation sufficient to bid, contract, and apply for progress payments from the project owner. ***Utilization of forms outlined in the project specifications takes precedence over the forms that are referred to in the instructions listed below***. It is likely that there are "Other" documents required by your specifications.

Components of this category to be assessed:

H.1 – Bid Proposal Documentation (25%)

Bid proposal completed correctly, including (but not limited to):

- Appropriate bid proposal form from project specifications utilized
- Alternates, allowances, unit costs, and contingency requested by the owner noted on bid proposal
- Bid bond documentation, if required
- Certificate of insurance documentation
- Other items as required by your project's specifications

H.2 – Owner-Contractor Contract Documentation (25%)

Project contract executed correctly, including (but not limited to):

- Appropriate contract from project specifications utilized
  - The AIA A101 Standard form of agreement between Owner and Contractor where the basis for payment is a stipulated sum should be used if a contract is not included and/or called for in the specifications.
- Performance bond documentation
- Payment bond documentation (if applicable)
- Schedule of Values to be used for progressive applications for payment
  - Lump Sum basis for payment, properly formatted based on the project specifications (AIA G703 if not specified otherwise)
  - General Conditions and OH&P properly distributed within the scheduled values
  - Cover transmittal for SOV submission by the GC to the A/E and Owner
- Other items as required by your project's specifications

H.3 – Contractor-Subcontractor Contract Documentation (25%)

One subcontract executed correctly, including (but not limited to):

- Detailed scope of work attached to subcontract
- Listing of project documents (i.e., plans and specifications) attached to subcontract
- Other items as required by your project's specifications

H.4 – Owner-Contractor Change Order Documentation (25%)

One change order between the Owner and Contractor executed correctly, including (but not limited to):

- Change order prompting from Owner and/or Owner's representative (i.e., Architect)
- Appropriate technology leveraged to determine material quantities
- Quantity take-off summarized in an appropriate and easy to follow fashion
- Quantities taken-off and incorporated into the estimate form using the appropriate units of measure

- Change order estimate
- Change order proposal form to be submitted to the Owner for approval
- Executed change order form (to be completed during the first three months of construction)
- Other items as required by your project's specifications

I. Payment Application and Cash Flow (10 points total)

Provide clear methods and recap of the cost loading of the project schedule, including how general conditions, corporate overhead, and profit are allocated. For the first three monthly pay periods, provide each of the following: evidence of schedule progress updates, data from the updates used to report period costs on the SOV, and the application for payment. The executed change order should be reflected at some point within these three months. Finally, show a clear analysis of project cash flow, identifying the maximum cash outlay by the general contractor for each month of the project.

Components of this category to be assessed:

I.1 - Cost Loading (25%)

Logical, organized, and accurate determination of the cost loaded value for each schedule activity:

- Clearly show how direct costs of activity values are determined.
  - Subcontracted scopes by realistic % of subcontract value
  - Self-performed scopes showing calculations
  - Hybridized scopes (sub+self, multiple sub, etc.) accurate, and relevant
  - All calculations/values (sub and self) clearly audited backwards to the estimate
  - All calculations/values clearly audited forward to the SOV
- Clearly show how the distributed/prorated general conditions, corporate overhead, and profit percentage (i.e., the spread) is calculated.
- If any, clearly show how allowances and contingencies are handled in the cost loading and the SOV.

I.2 - Updates and Applications for Payment (25%)

Provide updates and application for payment for months 1, 2, and 3 of the project (all items below to be provided for each of the first three months):

- Graphic schedule updates, showing completed activities (partial and full), can be cropped to the portion of the schedule relevant to the month.
- Reports of 'costs to date' based on progress, and the calculation of 'Total Completed and Stored to Date' (progress can be 'as planned', or with modifications); sorted and subtotaled based on the SOV.
- Realistic stored materials, and how they are incorporated into the 'Total Completed and Stored to Date.'
- Appropriate payment application form (AIA G702/703; Building Commission; others as specified), accurately compiled based on monthly updates from the cost-loaded schedule
- Proper execution of applications by GC.
- Incorporation of properly executed Change Order #1, sometime during the first three months including contract value and SOV (work does not have to be completed during this period).

I.3 - Cash Flow Analysis (25%)

Provide a comprehensive cash flow analysis, including how values are calculated:

- Description/definition/summary of all relevant factors (mark-up, % of work self-performed, retainage for GC and Subs, etc.)
- Plot of 'Earned Value' (EV) for the overall project.

        - Including ‘cash in’ and ‘cash out’ plotted based on calculated updates from the reports and the relevant factors described above.
    - Calculation of GC’s capital outlay (monthly ‘cash position’ just before payment from Owner), accurately based on schedule updates and relevant factors
    - Summary of evaluation of cash flow risk for the project, based on calculated capital outlay, maximum 200 words.
    - Clear understanding demonstrated in the student presentation.

I.4 - Cross-Component Relevance (15%)

The applications for payment and cash flow analysis are comprehensively relevant and reflective of other thesis components:

- Self-performed scopes in cost loading and pay apps are accurate based on the estimate.
- Distributed/prorated general conditions, corporate overhead, and profit are accurate based on the estimate.
- Stored materials relevant to the project schedule.

I.5 - Presentation (10%)

Present a summary of the earned value and cash flow in the presentation, highlighting maximum cash outlays over the life of the project. Present major factors’ impact on the project’s cash flow, such as retainage, amount of self-performed work, mark-up, etc.

J. Incorporation of "Unforeseen Incident" Scenario (5 points total)

Each thesis semester the description of an unforeseen incident will be presented to the thesis class during the ninth or tenth week of the spring and fall semesters, and the fifth or sixth week of the summer semester. The incident will be different each thesis semester. Your task is to develop a strategy (summarized in a written narrative, followed by pertinent back-up information) to address the unforeseen incident in the context of your individual project, and incorporate this strategy into your final thesis submission.

Components of this category to be assessed:

J.1 - Cost factors (25%)

Pertinent factors from unforeseen incident scenario affecting project cost addressed, including (but not limited to):

- General conditions
- Subcontracted work
- Self-performed work
- Bonding
- Change order development and execution
- Schedule of values/billings
- Contingencies
- Allowances

J.2 - Schedule factors (25%)

Pertinent factors from unforeseen incident scenario affecting project schedule addressed, including (but not limited to):

- Activity durations
- Total project duration

Milestone dates

J.3 - Relationship factors (25%)

Pertinent factors from unforeseen incident scenario affecting relationships between project stakeholders addressed, including (but not limited to):

- Owner-contractor working relationship
- Contractor-subcontractor/supplier working relationships
- Contractor-designer working relationship
- Contractor-public at large relationships
- Intra-organizational working relationships (i.e., within your own firm)

J.4 - Presentation (25%)

Unforeseen incident response presented correctly, including (but not limited to):

- Mitigation strategy clearly addressed
- Cost, schedule, and relationship factors clearly addressed
- Other items to convincingly defend your position and response

K. Student Selected Work (10 points total)

Students will direct/choose a portion of the thesis deliverables for topics in which they have a particular interest. This is accomplished by including relevant information, investigation, and/or evidence of activity of their choosing into their thesis submission. The deliverables should be insightful and demonstrate additional understanding of the thesis project beyond the prescribed deliverables. Aside from the deliverables approved within the submission of the Project Plan, the student is required to include a written reflection (approximately 300-500 words) about their learning experience with this student selected work.

The Student Selected Work submitted must involve **approximately 25 hours of work** completed by the student. Examples of "Student Selected Work" are listed below, but students are NOT required to choose from this list. Students should, however, seek feedback and approval from the faculty reviewer of their project plan on their proposed student selected.

If the student decides to change what will be done as part of their student selected work after the project plan has been submitted and approved, the student must resubmit their ideas to the thesis instructor and receive written approval. This approval must come at least two weeks prior to the final thesis submission deadline.

Potential Ideas:

Cost Analysis: Value engineering study for select components of the project, including impact on price, schedule, quality, life cycle, etc.

Temporary Structures: In addition to the temp structure analysis required in the thesis, students could perform an in-depth project specific investigation of trenching, bracing, shoring, or formwork. The complete design could include sketches, citations from applicable codes or OSHA sections, connection details, construction sequencing and other relevant information.

Scheduling: Provide an in-depth analysis of how the project might be expedited at the Owner's request, including sensitivity analyses of which activities/phases to shorten, cost to expedite, potential threats, etc.

Advanced Technology: Students could leverage new technology to investigate project specific facets of their project, such as UAV, robotic total stations, LiDAR scanning, advanced BIM, etc.

Cost of Capital: Perform a 'daily' analysis of project cash flow, including projected coast of capital, current interest rates, etc., to determine the net cost of financing over the life of the project.

Other Stuff: Get creative. Must be relevant. Make it interesting. Learn something. Raise the bar. This is worth a whole letter grade on your project.