Residential Garage Addition: Final Proposal

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Spring 2017 NORTHERN ARIZONA UNIVERSITY

CENE 476: Capstone Preparation

TABLE OF CONTENTS

Project Understanding 4

1.1 Project Background and Purpose 4

1.2 Technical Considerations 5

1.2.1 Feasibility and Site Investigation 5

1.2.2 Structural Analysis 5

1.2.3 Drafting and Construction Documents 6

1.3 Potential Challenges 6

1.4 Stakeholders 6

Scope of Services 7

Task 1.0 Code Research 7

Task 2.0 Survey and Site Analysis 7

Task 2.1 Identifying Setbacks 7

Task 2.2 Control Setup 7

Task 2.3 Surveying 8

Task 2.4 Mapping 8

Task 3.0 Conceptual Design 8

Task 4.0 Structural Design and Analysis 8

Task 4.1 Load Determination 8

Task 4.2 Truss Analysis and Design 8

Task 4.3 Joist Analysis and Design 8

Task 4.4 Beam Analysis and Design 9

Task 4.5 Header Analysis and Design 9

Task 4.5.1 King and trimmer stud Analysis and design 9

Task 4.6 Column Analysis and Design 9

Task 4.7 Foundation Analysis and Design 10

Task 4.8 Shear Wall Design 9

Task 4.9 Connection Analysis and Design 9
Task 5.0 Deliverables and Drafting Services 10
Task 5.1 50% Construction Documents 10
Task 5.2 Final Construction Documents 10
Task 5.3 Construction Drawing Standards 10
Task 5.4 Website 10
Task 5.5 Reflection Document 10
Task 6.0 Project Management 11
Task 6.1 Team Meetings 11
Task 6.2 Client Meetings 11
Exclusions 11
Impacts 11
Project Schedule 11
Cost of Engineering Services 11
4.1 Qualifications 12
4.1.1 PM 12
4.1.2 SSE 12
4.1.3 LS 12
4.1.4 EIT 12
4.1.4 HCR 12
4.2 Staffing Analysis and Engineering Cost Estimate 12
References 13

LIST OF FIGURES

Figure 1: Map of Munds Park relative to Flagstaff, AZ

1 PROJECT UNDERSTANDING

1.1 PROJECT BACKGROUND AND PURPOSE

Mark Haven has requested that Team Hawkeye design a two-car, two-story garage or carport addition to his residence in Munds Park, Arizona. Mr. Haven's residence is a pre manufactured home located on his approximately 6500 square foot property. The residence does not currently have a garage. The existing driveway serves as parking for Mr. Haven's vehicles: two trucks and a small snowplow. The proposed location of the garage addition is on the north side of the residence, along the existing driveway and facing Trout Creek Road (the street north to the lot). Generally, the dimensions for a two-car single story garage are approximately 20 feet in width, 20 feet in depth, and 10 feet in height. However, to accommodate three vehicles, the approximate dimensions of the proposed garage are 24 feet in width (for additional storage on the first floor), 25-30 feet in depth, and 15-20 feet in height.

Figure 1 Map of Munds Park Relative to Flagstaff, AZ

Munds Parks is a rural, unincorporated census-designated place in Coconino County, Arizona [1]. It is located approximately 19 miles south of Flagstaff, AZ. Munds Park experiences an average snowfall of 70 inches per year [2]. The owner's requires a garage for accessibility to his three vehicles during harsh weather conditions in the winter. Mr. Haven's secondary needs for a garage are storage for his personal property and a den/photography studio on the second floor of the garage. Mr. Haven requires the structure to be highly accessible on both floors, durable, and

have a unique design that allows for natural light on the second floor.

1.2 TECHNICAL CONSIDERATIONS

Team Hawkeye intends to assess the feasibility of the project, draft initial designs, provide a structural analysis and design, and provide final design drawings and recommendations.

1.2.1 Feasibility and Site Investigation

A site investigation of the Haven lot is required to assess the feasibility of this project. The site investigation will primarily consist of a land survey of the property. The survey of the property will determine setback boundaries and identify potential leveling issues. Surveying will identify the existing site characteristics, which will improve the design accuracy.

The team will be required to identify control points prior to the start of surveying. Control setup will serve as a reference point to establish consistent and accurate surveying data. The team will determine accurate distances of points on the property by using the control points as a reference during surveying. The team will then need to create a site plan; which should include boundaries created by setbacks, the dimensions of the existing residence, driveway, and location of existing landscape. Mapping and developing a site plan will require CAD software for the integration of survey data and CAD drawings.

Team Hawkeye will access the feasibility of the project after the site investigation. The team will need to identify all potential problems that the owner or the team have not yet identified from the initial meeting/site visit. The potential problems that the owner and team have already identified are detailed in section 1.3 Potential Challenges.

1.2.2 Structural Analysis

The team will reference the Coconino County Building Code and Zoning Ordinance, the 2012 International Building Code, the International Residential Code, and ASCE standards to determine all loads acting on the structure. Lateral loads and gravity loads (including snow loads, snowdrift loads on the walls, and wind loads) for the structural analysis of the garage addition will be determined using the aforementioned building codes.

Dead loads are constant gravity loads in a structure that are due to the weight of its members, the supported structure, and permanent attachments or accessories [6]. Live loads are any loads that are not attached to the building, such as people and furniture. The structural design of the garage will account for dead loads (due to the beams, columns, joists, headers, walls, trusses, roof material, interior fixtures, drywall, floor, and elevator)

and live loads (vehicles, people, etc).

Lateral loads from wind or seismic forces produce a horizontal force that acts on the structure. Wind loads are lateral loads that account for the force of the wind hitting the side of the building. Seismic loads account for the side-to-side, or vertical motion that the ground would be doing during an earthquake. The soil's bearing capacity will influence the structures ability to resist seismic loads. The team will use the "worst-case" allowable soil bearing capacity when designing the garage. This will ensure the structural integrity of the building despite the possibility of poor soil on the lot.

1.2.3 Drafting and Construction Documents

A final set of technical drawings will include the site plan of the property. As previously stated, the creation a site plan will require surveying to determine the exact square footage and boundaries the proposed garage must be located. The Coconino County Building Ordinance lists the other technical drawings that are required for a residential addition. The team will provide the structural schematics and technical drawings listed in the CCBO, with detail views of all necessary components of the garage or carport, that are required for the approval of the garage addition by Coconino County Community Development Department.

1.3 POTENTIAL CHALLENGES

The primary challenge for the garage addition is small buildable area. There must be a 15' front setback, a 5' side setback, and a 15' rear setback for a manufactured home on a 6,000 square foot lot. An existing utility line is located between the owner's lot and the property west of the lot. A 5' utility easement is also required. The utility easement will further restrict the area in which the garage must be located. In situations where a utility easement is located along a property line, the setback shall be measured from the interior edge of the Access Easement line. Where an Access Easement bisects any parcel of land, said easement shall be considered a Street for Setback purposes and Street Side Setbacks shall apply [2].

The owner has also required that the tree east of his existing driveway not be moved or disturbed. This also limits the buildable area of the garage. A variance permit will be required to extend the setback boundaries for a realistic buildable area. The team will be required to research and provide the construction documents needed to obtain a variance permit.

1.4 STAKEHOLDERS

The client, Mark Haven, is the primary stakeholder for this project. As the owner of the property,

the client stands to benefit the most from the addition of a garage or carport. Mr. Haven has a direct need for garage design and is the main financial investor, thus is a stakeholder in the outcome of the project. Team Hawkeye is also a stakeholder, as the team will invest time and resources into the success of the project. Failure to meet the owner's criteria and expectations will adversely affect the team. The future contractor will also hold a stake in the successful completion of this project. The future contractor will use the technical drawings from this project to complete construction. Therefore, drawings must be easily understood and effectively communicate design of the garage addition.

2 SCOPE OF SERVICES

TASK 1.0 CODE RESEARCH

The team will research and refer to building codes throughout the entirety of the project to ensure the proposed garage follows Coconino County Building codes and international standards. All relevant criteria (i.e. structural design loads and setback distances) will be researched and followed until the completion of the project. The building codes will include:

- Coconino County Building Ordinance
- International Building Code 2012
- International Existing Building Code 2012
- International Residential Code 20
- Coconino County, Arizona Zoning Ordinance [3]

Other standards and codes may be used in the structural design that are not listed above.

TASK 2.0 SURVEY AND SITE ANALYSIS

A survey will be conducted to establish the layout of buildable area. The surveyors will take measurements of the boundaries of the garage and utilities.

Task 2.1 Identifying Setbacks

The team will research zoning ordinances of Coconino County to provide zone classification of the existing homes and to reference setback measurements (15' front setback for a residential manufactured home).

Task 2.2 Control Setup

Control points will be used to measure horizontal and vertical positions in the coordinate systems. The team will determine control points by setting up a GNSS base station to calibrate the site by using an existing coordinate system [4]. The calibration will combine projections, datum grids, and angles of the building. The group will establish benchmarks on the property to ensure accurate data collection for the rest of the survey.

Task 2.3 Surveying

The group will conduct a land survey of the property using a total station and prism rod. The group will survey the property, including the existing residence, driveway, landscape, and grade (slope) of the lot. The locations of existing property lines will also be determined. Once data has been collected with the total station and prism rod, the group will store the data on a data logger.

Task 2.4 Mapping

The team will produce a topographic map and site plan of the Haven lot. The team will use the data logger to upload points to the Civil 3D, then produce a map with elevations, distances of designated points on the lot. The site plan will include boundaries created by the required easement and setbacks, the existing residence, existing driveway, existing landscape, and the proposed location of the garage.

TASK 3.0 CONCEPTUAL DESIGN

Three distinctly different architectural designs for the garages addition will be presented to the client. These conceptual designs will communicate the general form and function of the structure (i.e. general garage door and window location, preliminary dimensions, and basic aesthetic concepts). The team will draft and present conceptual designs to the client as a floor plan and preliminary sketch of the exterior.

TASK 4.0 STRUCTURAL DESIGN AND ANALYSIS

Task 4.1 Load Determination

The team will determine all dead loads, live loads, seismic loads, lateral/wind loads, and snow loads using the building codes detailed in Task 1.0.

Task 4.2 Truss Analysis and Design

The group will choose premanufactured trusses for the roof that support the required loads. RISA-2D is a software will be used for structural design and analyze structural loads and beams. Hand calculations will also be used to determine bending moments, shear, and deflection criteria for the roof and the other structural elements listed in in the following tasks.

Task 4.3 Joist Analysis and Design

Joists provide the structural integrity of the floor above the foundation and slabs. They will be spaced at an even distance to allow for easier constructability and reduce future construction costs. Joists will be designed according to the dead loads, live loads, snow loads, and wind loads that will be determined in previous tasks.

Task 4.4 Beam Analysis and Design

Beams are members that run perpendicular to columns. Beams will be designed to withstand bending moments, shear, and axial forces that cause plastic deformation and failure. Beams will be designed to resist dead loads, wind uplift loads, snow loads, and live loads (determined in previous tasks).

Task 4.5 Header Analysis and Design

Headers are framing members that cross and support the ends of joists, studs, or rafters to transfer their weight to parallel joists, studs, etc. Headers create the opening that becomes the window or door frame. Headers will be designed to withstand bending moments, shear, and axial forces. Headers will be designed to resist dead loads, live loads, snow loads, and wind loads.

Task 4.5.1 King and trimmer stud Analysis and design

King studs are the main studs that run the height of the walls. Trimmer studs are studs that are the height of windows and doors, but do not frame into the floor and ceiling simultaneously. King studs and trimmer studs will be designed as necessary to frame into headers.

Task 4.6 Column Analysis and Design

Columns are the end supports on walls that will hold the weight of the beams and other structural members located on top of the beams. Columns will be designed to withstand the point loads from the beams.

Task 4.7 Foundation Analysis and Design

The foundation of the building is the concrete pad that the building will sit on. Foundation size and reinforcement will be determined from the load generated by the building, as well as, the minimum bearing capacity of the soil. The foundation will be designed to prevent failure in the soil (i.e. bearing capacity failure, overturning, uplift, and sliding). The required cut and fill of the existing soil will be determined to ensure the proper leveling of the structure. This will be determined using hand calculations and the topographic map [5].

Task 4.8 Shear Wall Design

Shear walls are the walls that are designed to counter the lateral loading and prevent lateral failure. Shear walls will be designed as necessary to withstand shear forces (i.e. wind and seismic forces).

Task 4.9 Connection Analysis and Design

Connections are the pieces that connect the structural members together, such as a header to a trimmer stud. Connections will be chosen from pre-manufactured options based on cost and strength.

TASK 5.0 DELIVERABLES AND DRAFTING SERVICES

This task includes the drafting and submittal of final construction documents for structural design of the garage addition. The documents that will be provided are detailed below.

Task 5.1 50% Construction Documents

As the structural design progresses, technical drawings will be developed and will evolved from the start of conceptual design to the end of the project. 50% construction documents will be provided to the owner to show progress during the halfway point of the structural design phase. All construction documents listed under 4.3 deliverables will be drafted in AutoCAD 2010 or newer.

Task 5.2 Final Construction Documents

Minimum requirements to obtain a building permit in Coconino County are as follows: User must submit a Foundation Plan (footings, stem walls), Floor Framing Plan (i-joist system & framing & connectors), Floor Plan (windows, emergency exits, etc), Electric Plan (excluded), Elevations, Roof Framing Plan (headers, load bearing beams, ceiling joists, etc), Cross sections (all dimensions), and Details (for footings & and connections). The team will submit a final report to the client that consists of the aforementioned plans required by Coconino County and a preliminary site plan (1"-5'-0) detailing the lot geometry, existing driveway, setback boundaries, etc. The final report and construction documents will include a detailed narrative of design rationale, specific building code sections that were referenced, justification of design load assumptions, and all structural calculations.

Task 5.3 Construction Drawing Standards

Construction drawing standards will be created and used to ensure consistency in the construction documents. Title Blocks will contain the following information: project name, designer/engineer name, drawing title, drawing number, date of drawing, scale, and north arrow. A hard copy and electronic copy (CAD drawings and PDF) of drawings will be provided to owner. Preferred hard copy size will be designated by the owner, however 24" x 36" will be provided for final plan set.

Task 5.4 Website

A website will be created to summarize the project objectives. The website will provide project documents (i.e. CAD drawings, presentations, and construction documents), team member information, and a gallery of project photos.

Task 5.5 Reflection Document

Personal reflection documents from each team member will be provided at the end of the project. Team members will reflect on the progression of the project and how ABET learning objectives were achieved.

TASK 6.0 PROJECT MANAGEMENT

Task 6.1 Team Meetings

The team will meet a minimum of once a week for the duration of the project to discuss the progress of the project, discuss ideas, and work on deliverables. The team will record meeting minutes that include meeting notes, new challenges and potential solutions, and action items to be completed. The team will plan less frequent meetings during the summer in order to continue progress during the summer break.

Task 6.2 Client Meetings

The team will have a minimum of two client meetings per Capstone course (CENE 476 Spring 2017 and CENE 486 Fall 2017). The first meeting, during the first semester, is delegated to the initial field visit and client introduction. The following meetings will be to update client on the progress of the project and discuss any of his concerns.

EXCLUSIONS

The following services are required for the completion of this project, yet will not be provide by Team Hawkeye: a geotechnical investigation of the subsurface soil of the property/lot, final architectural design, mechanical system, electrical system, plumbing, HVAC, fire safety and sprinkler systems analysis. The group will not check the design of the existing foundation and will not apply for building permits nor submit technical documents to Coconino County. The group will also be excluding floodplain analysis, as the proposed site is not in a FEMA floodplain. The project is limited to the Task 1.0 to Task 6.2 detailed in the Scope of Services.

IMPACTS

This project affects different parties in the area. The client will be mainly impacted financially by the cost of the project. There is a possibility that the views of the surrounding forest will be obstructed from neighbor due the second story of the garage. However, the property is located in a small community and on private land, thus a garage addition is not likely to have any political, cultural, or environmental impacts.

3 PROJECT SCHEDULE

The Gantt chart, which displays the project schedule, is located in Appendix A. The Gantt chart lists all major tasks and subtasks with a task start and end date. The arrow represents the critical path.

4 COST OF ENGINEERING SERVICES

This section includes the qualifications and position description of team members, costs of services, and estimated hours of service to the project.

4.1 QUALIFICATIONS

4.1.1 PM

Project Manager- The project manager will manage the project until it is completed. The job responsibilities of the PM include compiling and editing project documents (i.e. reports and presentations), scheduling meetings, interacting with the client, recording meeting minutes and itineraries, maintaining the project budget. The PM possesses leadership skills, time management skills, and critical problem solving skills.

4.1.2 SSE

Senior Structural Engineer- The structural engineer is responsible for overseeing the structural design and analysis. The SSE has knowledge of common construction materials such as steel, concrete, and wood, and will determine loads on the structure. The structural engineer has experience with foundations and multi-story buildings.

4.1.3 LS

Land Surveyor- The land surveyor will oversee and execute the surveying of the lot. The surveyor will obtain data of the lot for the development of a site map and contour map. The surveyor has experience in using a data collector and total station. They also process a familiarity with other instruments and methods to survey the lot. The land surveyor has knowledge of local government regulations, such as required easements and setbacks, to complete surveying.

4.1.4 EIT

Engineer in Training- The EIT will provide preliminary structural schematics and drawings and assist in all tasks. This position will help ensure the structural design is up to code and labor is equally distributed among tasks.

4.1.5 DS

Drafting Specialist- The DS will act as drafter for all deliverables. This position requires the study of international building codes and required documents to be submitted to Coconino County for the approval of the project.

4.2 STAFFING ANALYSIS AND ENGINEERING COST ESTIMATE

Appendix B provides the matrix that lists the hours required of each position and associated costs for each task, the total cost of overhead, and reimbursable expenses. Appendix C shows the billing rate calculations for each position.

REFERENCES

[1] "Munds Park, Arizona," 2017. [Online]. Available: http://www.city-data.com/city/Munds-Park-Arizona.html. [Accessed 07 02 2017].

[2] C. C. Arizona, "Coconino County Zoning Ordinance," 26 07 2016. [Online]. Available: http://coconino.az.gov/DocumentCenter/View/12230. [Accessed 27 01 2017].

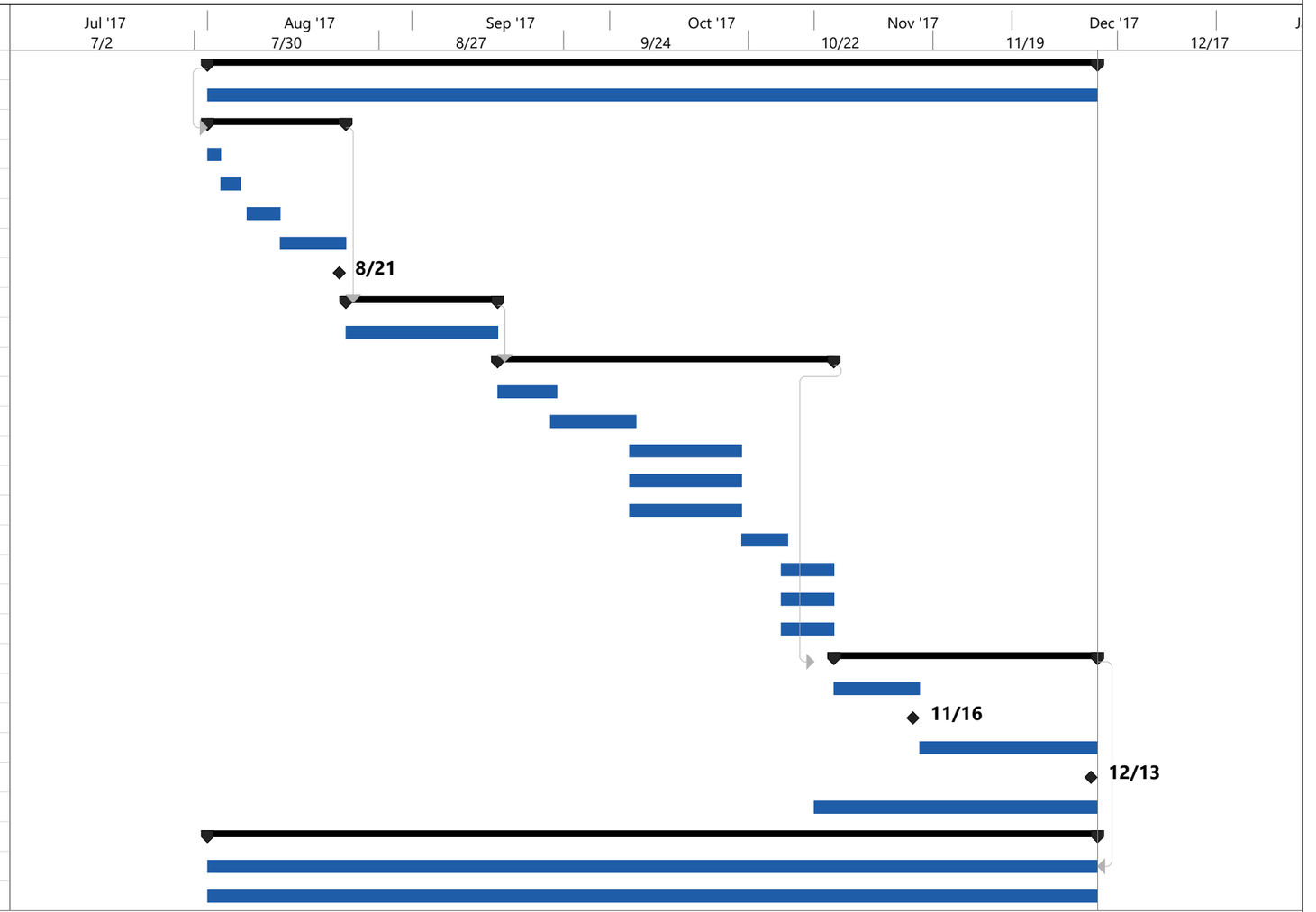
[3] Z*ONING ORDINANCE*, 1st ed. Coconino County, 2016, pp. 5-8.

[4] "Horizontal and Vertical Control," [Online]. Available: http://www.gresurv.com/hvcontrol.html. [Accessed 20 February 2017].

[5] Mott MacDonald Consultants, "Design Basis for Civil, Structural & Architectural," Mumabi, 2009.

Appendix A: CENE 476 Residential Garage Addition Gantt Chart

ID	Task Name	Duration	Start	Finish
1	**Task 1.0 Code Research**	**97 days**	**Tue 8/1/17**	**Wed 12/13/17**
2	Task 1.0 Code Research	97 days	Tue 8/1/17	Wed 12/13/17
3	**Task 2.0 Survey and Site Analysis**	**15 days**	**Tue 8/1/17**	**Mon 8/21/17**
4	Task 2.1 Identifying Setbacks	2 days	Tue 8/1/17	Wed 8/2/17
5	Task 2.2 Control Setup	3 days	Thu 8/3/17	Sat 8/5/17
6	Task 2.3 Surveying	5 days	Mon 8/7/17	Fri 8/11/17
7	Task 2.4 Mapping	7 days	Sat 8/12/17	Mon 8/21/17
8	**Surveying and Site Map Complete**	0 days	**Mon 8/21/17**	Mon 8/21/17
9	**Task 3.0 Conceptual Design**	**17 days**	**Tue 8/22/17**	**Wed 9/13/17**
10	Task 3.0 Conceptual Design	17 days	Tue 8/22/17	Wed 9/13/17
11	**Task 4.0 Structural Design & Analysis**	**37 days**	**Thu 9/14/17**	**Fri 11/3/17**
12	Task 4.1 Load Determination	7 days	Thu 9/14/17	Fri 9/22/17
13	Task 4.2 Truss Analysis and Design	9 days	Fri 9/22/17	Wed 10/4/17
14	Task 4.3 Joist Analysis and Design	13 days	Wed 10/4/17	Fri 10/20/17
15	Task 4.4 Beam Analysis and Design	13 days	Wed 10/4/17	Fri 10/20/17
16	Task 4.5 Header Analysis and Design	13 days	Wed 10/4/17	Fri 10/20/17
17	Task 4.6 Column Analysis and Design	6 days	Sat 10/21/17	Fri 10/27/17
18	Task 4.7 Foundation Analysis and Design	6 days	Fri 10/27/17	Fri 11/3/17
19	Task 4.8 Shear Wall Design	6 days	Fri 10/27/17	Fri 11/3/17
20	Task 4.9 Connection Analysis and Design	6 days	Fri 10/27/17	Fri 11/3/17
21	**Task 5.0 Deliverables and Drafting Services**	**29 days**	**Sat 11/4/17**	**Wed 12/13/17**
22	Task 5.1 50% Construction Documents	10 days	Sat 11/4/17	Thu 11/16/17
23	**50% Construction Documents Complete**	0 days	Thu 11/16/17	Thu 11/16/17
24	Task 5.2 Final Construction Documents	19 days	Fri 11/17/17	Wed 12/13/17
25	**Final Construction Documents Complete**	0 days	Wed 12/13/17	Wed 12/13/17
26	Task 5.3 Construction Drawing Standards	31 days	Wed 11/1/17	Wed 12/13/17
27	**Task 6.0 Project Management**	**97 days**	**Tue 8/1/17**	**Wed 12/13/17**
28	Task 6.1 Team Meetings	97 days	Tue 8/1/17	Wed 12/13/17
29	Task 6.2 Client Meetings	97 days	Tue 8/1/17	Wed 12/13/17



Appendix A: CENE 476 Residen

Task	Manual Task	Deadline	Path Driven Successor Normal Task
Split	Duration-only	Path Predecessor Milestone Task	Path Driven Successor Milestone Task
Milestone	Manual Summary Rollup	Path Predecessor Summary Task	Baseline
Summary	Manual Summary	Path Predecessor Normal Task	Baseline Milestone
Project Summary	Start-only	Path Successor Milestone Task	Baseline Summary
Inactive Task	Finish-only	Path Successor Summary Task	Progress
Inactive Milestone	External Tasks	Path Driven Successor Summary Task	Manual Progress
Inactive Summary	External Milestone	Path Successor Normal Task	Slippage

Appendix B: Staffing & Cost Estimate

Team Hawkeye- Civil Engineering Firm							
1.0 Engineering Services Hours							
	PM	**SE**	**LS**	**EIT**	**DS**	Subtaks Total Hours	Task Cost Estimate
Billing Rate ($/hr)	$125	$170	$60	$65	$70		
Task 1.0 Code Research	1	1		10		12	$945.00
						Task 1.0 Code Research Subtotal	**$945.00**
Task 2.0 Survey & Site Analysis							
Task 2.1 Setbacks				2		2	$ 130.00
Task 2.2 Control Setup	1		1	2		4	$ 315.00
Task 2.3 Surveying	4		15	5		24	$ 1,725.00
Task 2.4 Mapping	2		10		15	27	$ 1,900.00
						Task 2.0 Survey & Site Analysis Subtotal	**$ 4,070.00**
Task 3.0 Conceptual Design	2	2		2	15	21	$ 1,770.00
						Task 3.0 Conceptual Design Subtotal	**$ 1,770.00**
Task 4.0 Structural Design & Analysis							
Task 4.1 Load Determination	3	10		5		18	$ 2,400.00
Task 4.2 Truss A&D	1	12		25		38	$ 3,790.00
Task 4.3 Joist A&D	1	12		25		38	$ 3,790.00
Task 4.4 Beam A&D	1	12		25		38	$ 3,790.00
Task 4.5 Header A&D	1	12		25		38	$ 3,790.00
Task 4.5.1 King and Trimmer Stu	1	12		25		38	$ 3,790.00
Task 4.6 Column A&D	1	12		25		38	$ 3,790.00
Task 4.7 Foundation A&D	1	10		25		36	$ 3,450.00
Task 4.8 Shear Wall A&D	1	10		25		36	$ 3,450.00
Task 4.9 Connections A&D	1	12		25		38	$ 3,790.00
						Task 4.0 Structural Design & Analysis Subtotal	**$ 35,830.00**
Task 5.0 Deliverables And Drafting							
Task 5.1 50% and 75% Docs	4	2		5	80	91	$ 6,765.00
Task 5.2 Final Construction Docs	4			5	25	34	$ 2,575.00
Task 5.3 Construction Drawing Stand	2			3		5	$ 445.00
Task 5.4 Website	1			15		16	$ 1,100.00
						Task 5.0 Deliverables and Drafting Services Subtotal	**$ 9,785.00**
Task 6.0 Project Management							
Task 6.1 Team Meetings	15		1	2		18	$ 2,065.00
Task 6.2 Client Meetings	10					10	$ 1,250.00
						Task 6.0 Project Mangement	**$ 3,315.00**
Total Hours/Position (hr)	57	118	27	271	135	**620**	
						1.0 Engineering Services Total	**$ 55,715.00**

2.0 Overhead					
	Item	Rate	Unit	Amount (Hrs)	Cost
	Supplies	$ 0.93	$/hour	620	$ 576.60
	Administration	$ 2.81	$/hour	620	$ 1,742.20
	Survey Equipment Rental	$ 140.00	$/hour	28	$ 3,920.00
	Desired Profit	$ 2.13	$/hour	620	$ 1,320.60
				2.0 Total Overhead Cost	**$ 6,238.80**

3.0 Reimbursable Expenses			
	Miles per trip	Number of trips	
Travel (Gas)	41.8	5	
		3.0 Reimbursable Total	**$ 209.00**

Grand Total	
1.0 Engineering Services	$ 55,715.00
2.0 Overhead	$ 6,238.80
3.0 Remibursable Expenses	$ 209.00
Grand Total	**$ 62,162.80**

Appendix C: Billing Rate for Engineering Staff

Billing Rate Calculations					
Position	**Base Pay Rate ($/hr)**	**Employee Benefits (% of Base Pay Rate)**	**Company Profit (% of Base Pay)**	**Overhead (% of Base Pay)**	**Total Billing Rate ($/hr)**
PM	83.3	30	10	10	**124.95**
SE	94.5	60	10	10	**170.1**
LS	40	30	10	10	**60**
EIT	46.25	20	10	10	**64.75**
DS	46.6	30	10	10	**69.9**