2023-2024 ASCE TIMBERSTRONG

PROJECT PROPOSAL

Ponderosa TimberJacks
MARIAH BOLER, MOURTICE CLITSO, JENNA HAYS

OCTOBER 3, 2023
DRAFT #2

Contents

Table of Figures

Table of Tables

Appendices

List of Abbreviations

APA	American Plywood Association
ASCE	American Society of Civil Engineers
ASD	Allowable Stress Design
AWC	American Wood Council
BIM	Building Information Model
CECMEE	Civil Engineering, Construction Management, and Environmental Engineering
FTAO	Force Transfer Around Openings
ISWS	Intermountain Southwest Student Symposium
NAU	Northern Arizona University
NDS	National Design Specifications
OSB	Oriented Strand Board
SDPWS	Special Design Provisions for Wind and Seismic
SST	Simpson Strong Tie
USU	Utah State University

1.0 Project Understanding

1.1 Project Purpose

The purpose of the American Society of Civil Engineers (ASCE) TimberStrong Student Competition is to provide civil engineering students with real-world experience in structural timber design and construction. The American Wood Council (AWC), Simpson Strong Tie (SST), American Plywood Association (APA), and ASCE are seeking ASCE Student Teams to act as a design-build construction firm and create a two-story light-framed lumber building that is structurally durable, aesthetically pleasing, and sustainable. This competition exposes students to various aspects of the structural engineering and construction industries, including design and analysis calculations, design code navigation, structural drawings, Building Information Modeling (BIM), and construction planning and execution.

1.2 Project Background

1.1 Northern Arizona University (NAU) ASCE students have been participating in TimberStrong since the inaugural competition in 2018. The project scope has evolved from a scaled ‘doghouse,’ to a full two-story, twelve-foot-tall timber house over the competition lifetime. The dimensional constraints for the structure are shown in Appendix 0. The stages of the project are shown in Figure 1-1.

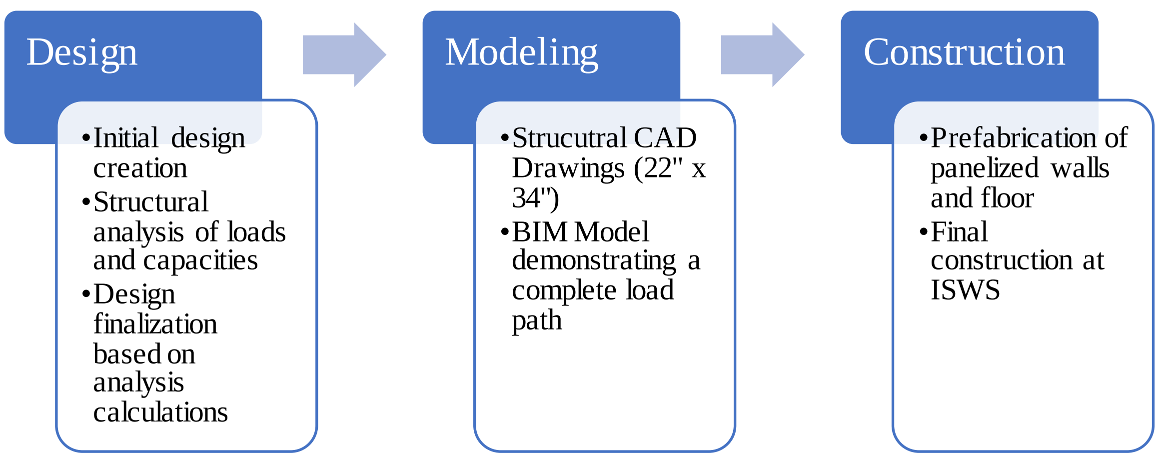

Figure 1- 1: Project Stages

Prefabrication construction will take place at the NAU ‘Farm,’ officially titled the Civil Engineering, Construction Management, and Environmental Engineering (CECMEE) Field Station. The location of the project within Arizona and NAU within Flagstaff is shown below in Figure 1-2.

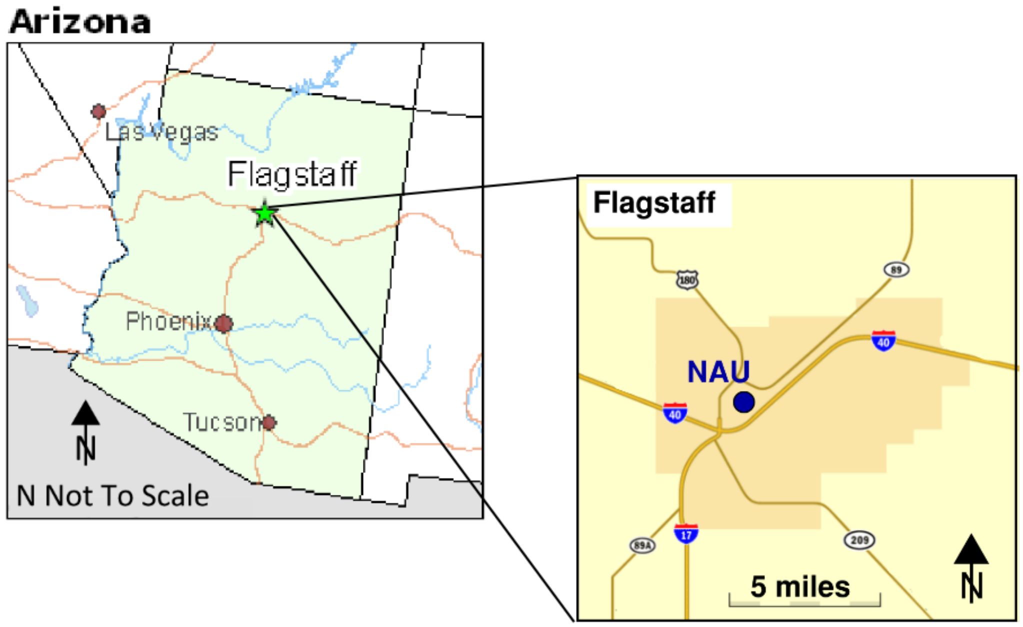

Figure 1- 2: Location Maps of Flagstaff, Arizona [1] [2]

Final construction will occur during the ASCE Intermountain Southwest Student Symposium (ISWS) at Utah State University (USU) in Logan, Utah in April of 2024. The location map of Logan within Utah is shown below in Figure 1-3.

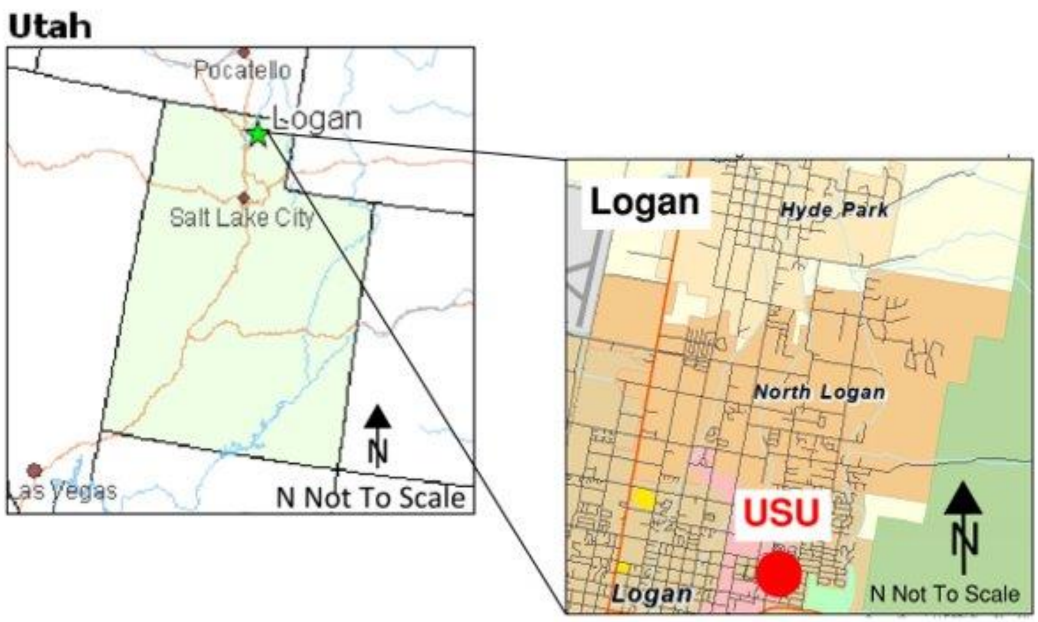

Figure 1- 3: Location Map of Logan, Utah [1]

1.3 Technical Considerations

1.3.1 Structural Requirements

The structural design is required to use the Allowable Stress Design (ASD) method to ensure that stresses caused by applied loads do not exceed design capacities. Structural design shall be completed in accordance with the AWC Special Design Provisions for Wind and Seismic (SDPWS) [3] and the AWC National Design Specifications (NDS) [4]. The design must demonstrate a complete and continuous load path for both gravity and lateral loads through the structure and into the foundation. Demonstration of load path can be seen below in Figure 1-4.

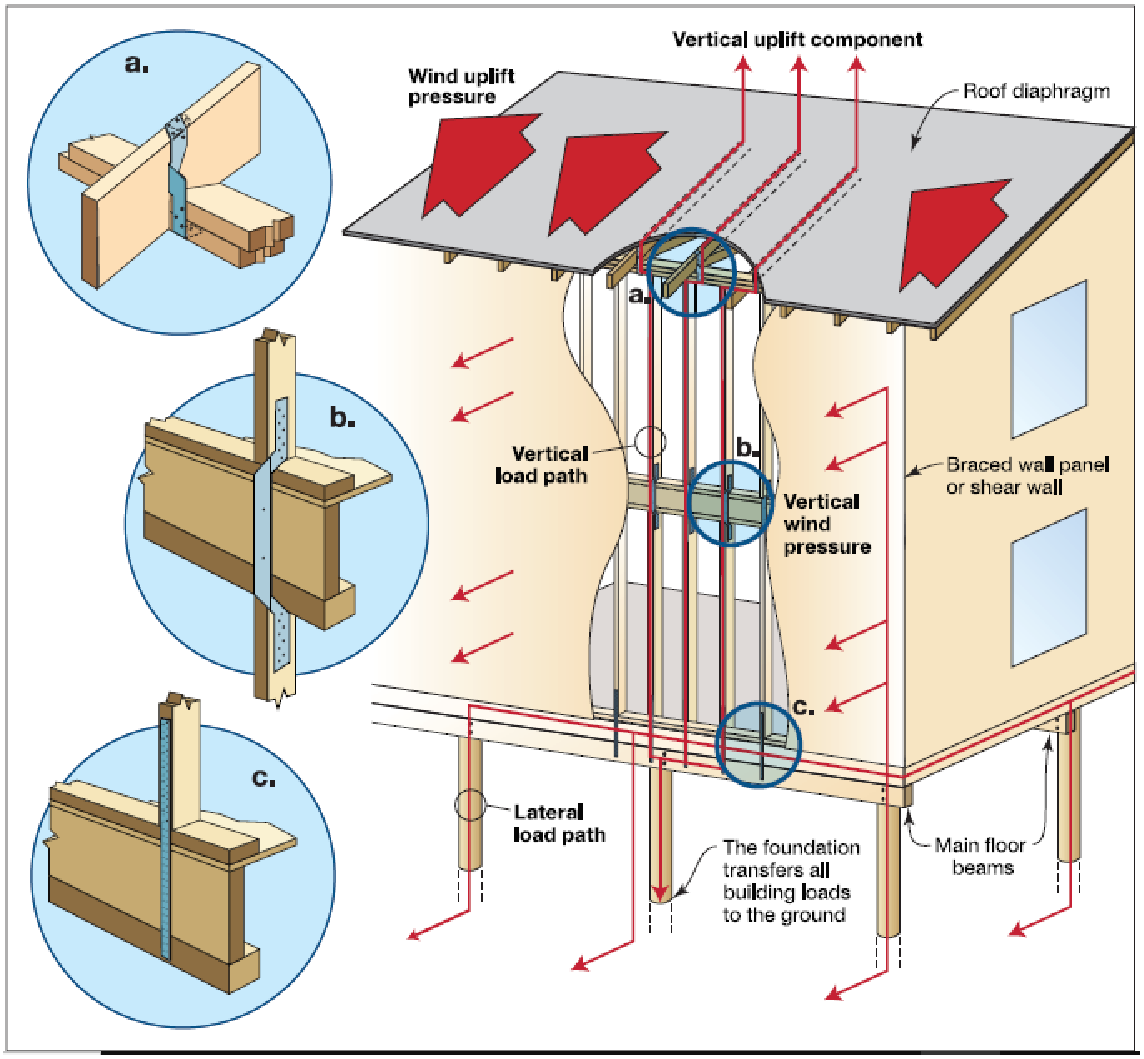

Figure 1- 4: Load Path [3]

The structural design of the project requires that the proposed timber structure can withstand all self-weight dead loads and the following loads established by the TimberStrong Competition Rules. The structure loads required can be found in Table 1-1 below.

Table 1- 1: Structure Loads

Load Type	Load Value
Live, Roof	20 psf
Live, Second Floor	50 psf
Point Load, Cantilever	150 lb
Wind Uplift, Roof	30 psf
Seismic, Roof Diaphragm	275 plf
Seismic, Second Floor Diaphragm	225 plf

1.3.2 Timber Grade

Softwood is used in residential construction as it is cheaper than hardwood and provides the necessary strength for the loads and design scope of these structures. Common wood types used in residential construction include cedar, pine, Douglas fir, redwood, and hem fir. Hem fir will be used for this structure as it is commonly used in residential construction due to the fact that it provides the necessary strength capacities without overdesigning [4].

Softwood is categorized on a grading scale of No.1 through No. 5. Grade No. 1 is the strongest and contains the least imperfections in the form of warping and knots. Grade No. 5 has many imperfections and cannot handle large loads. Grade No. 2 wood will be used for this project, as this grade provides the necessary strength needed for stable construction and the ability to withstand the expected loads [5].

1.3.3 Gravity and Lateral Design

1.3.3.1 Gravity Design

The gravity design of the structure is based on the self-weight dead loads, the cantilever beam point load, and the roof and second floor live loads. The cantilever floor beam shall be designed for shearing and bending and must match a calculated deflection within 0.5 to 1 in. at 4 ft from the exterior wall.

1.3.3.2 Lateral Design

Lateral design of the structure is required to withstand the given seismic and wind loads for the following elements:

- Diaphragms, including sheathing, chords, and collectors, for in-plane shear in both structure directions.
- Shear walls for in-plane shear and overturning
- Anchorage for the roof joists and the foundation, including reinforcement types such as hold-downs and anchor bolts.

The applied lateral and gravity loads, from a variety of angles, can be seen in Figures 1-5 through 1-8 below.

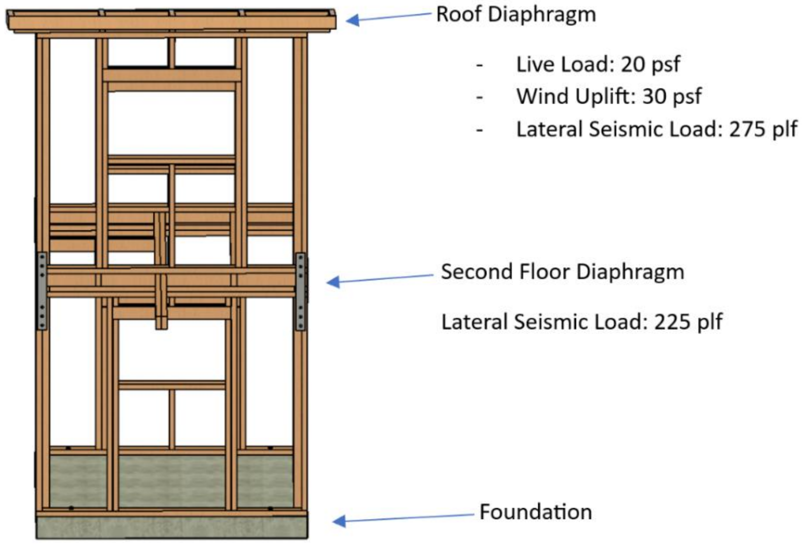

Figure 1- 5: Front View of Applied Loads

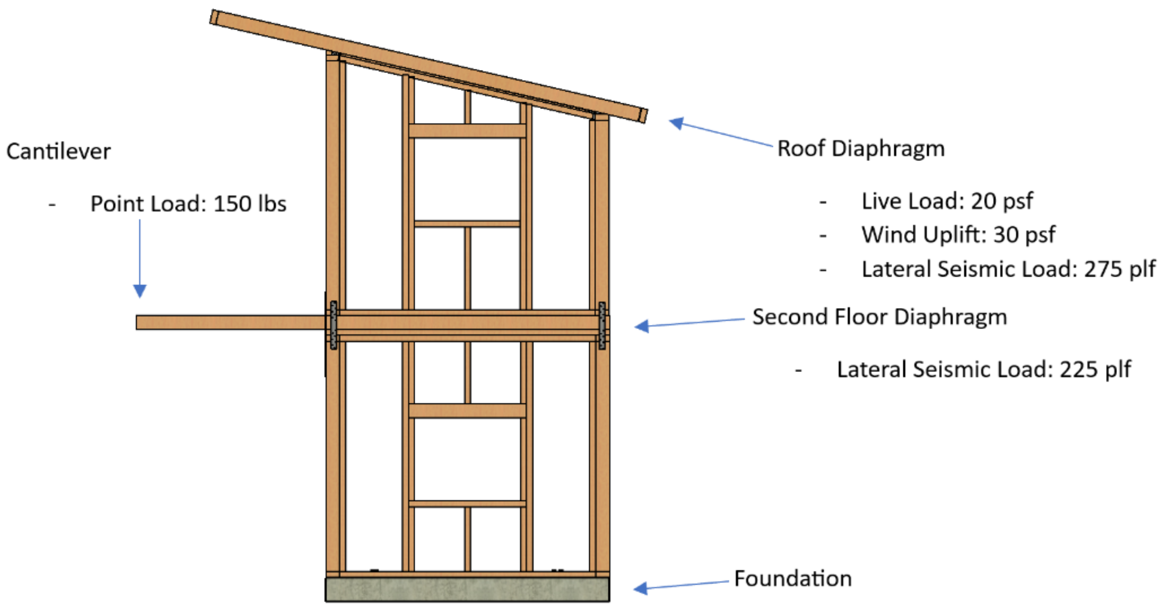

Figure 1- 6: Side View of Applied Loads

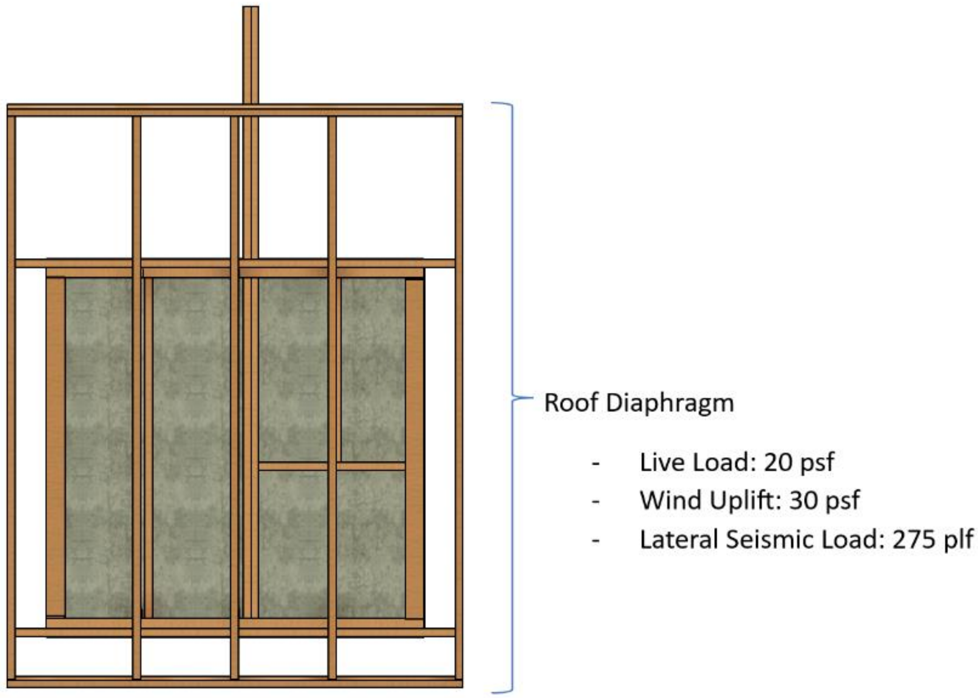

Figure 1- 7: Top-Down View of Applied Loads

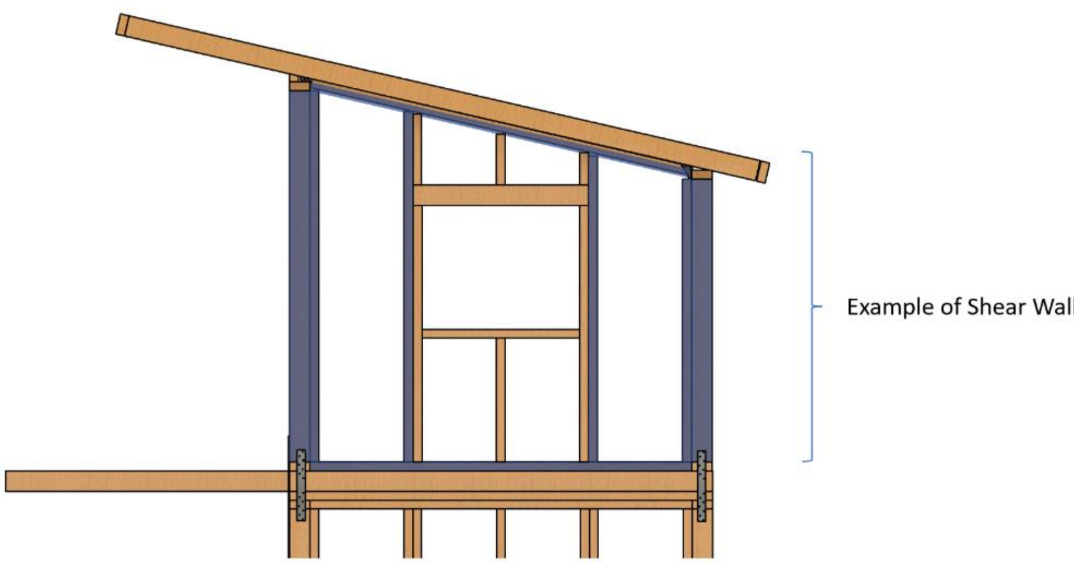

Figure 1- 8: Shear Wall Example

1.3.4 Construction

Most of the construction process will take place over three to seven days in multiple phases at the Farm. Organization and inventory of all materials and tools available at the Farm will occur during the fall semester. The three phases of the construction process are shown below in

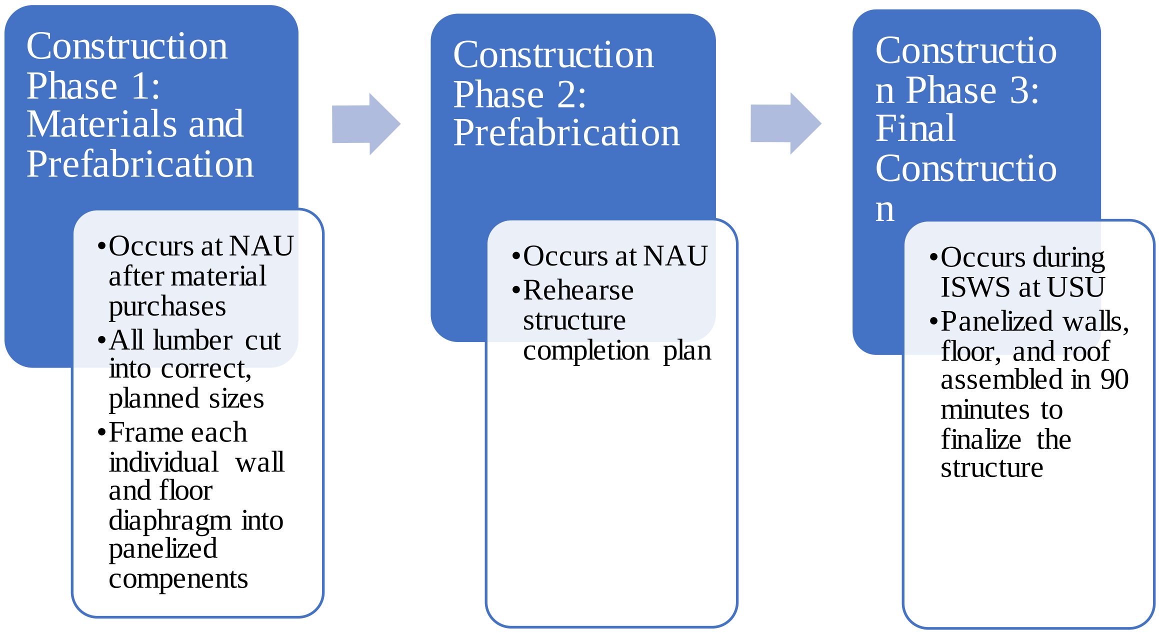

Figure 1- 9: Construction Process

1.3.5 Testing & Scoring

Report scoring for the design and modeling phases provides a maximum of 290 points and are based on the following sections as seen in Table 1-2 below.

Table 1- 2: Report Scoring

Report Scoring	Maximum Points
Design Strength and Durability Analysis	82
Sustainability	18
Costs	20
Creativity and Aesthetics	20
Presentation	11
Visual Aid	9
Report Requirements	10
BIM	70
Construction Drawings	50
Design Points Possible	290 (+5 bonus)

Sustainability will be determined from the design's potential carbon benefit and calculated carbon sequestration. Budget costs will be scored relatively between teams; the team with the lowest budget is awarded the most points. Creativity and aesthetics are a subjective score given by the judges.

During the construction phase at ISWS, the first floor will be tested for structural stability before building the top floor. After all construction is completed at ISWS, the structure will be tested by applying the cantilever point load and measuring the deflection. The cantilever deflection is included in the Design Strength and Durability Analysis category and is scored on the ratio of predicted to actual deflection within the allowable range. The subsections of the Design Strength and Durability Analysis category scoring is shown below in Table 1-3.

Table 1- 3: Design and Durability Scoring

Design and Durability Scoring	Maximum Points
Diaphragm Factor of Safety	6
Shear Wall Factor of Safety	6
Completeness and Accuracy of Calculations	55
Deflection	15
Design and Durability Points Possible	82

The subsections of the BIM model category scoring are shown below in Table 1-4.

Table 1- 4: BIM Scoring

Construction Scoring	Maximum Points
Accuracy of Model	30
Load Path	20
Complete Structure	20

The scoring of the construction portion of the competition will be based on the following sections as seen in Table 1-5 below.

Table 1- 5: Construction Scoring

Construction Scoring	Maximum Points
Consistency/Accuracy	130
Continuous Load Path	
Completion of Structure	
Build Time (Bonus)	5
Construction Points Possible	130 (+5 bonus)

The maximum construction points awarded, 130 points, will be distributed among the categories of consistency/accuracy of the completed structure to the structural drawings submitted, the continuous load path that is demonstrated in the structure, and the constructed completion of the structure on competition day. There will also be bonus points awarded to the first team to finish the construction of their structure.

1.4 Potential Challenges

1.4.1 Acquiring Funds

The ASCE TimberStrong Design Build Student Team will acquire funds through sponsorships and crowdfunding. The budget for the design will require sponsorship from multiple firms and/or donors due to the large amount of lumber, OSB, paint, screws/connections, and tools necessary for the project. This large budget will pose a potential challenge to the team if sponsor interest is low. Additionally, budget modifications could be challenging to handle if issues with materials or tools arise, causing the budget to increase unexpectedly.

If sponsorship funding is low, the student team must allocate the funds to the most important elements of the construction including lumber, plywood, and screws. In this case, the aesthetic materials needed such as paint, paintbrushes, stencils, will need to be found within the engineering building at NAU, donated, or not used at all.

1.4.2 Protection During Prefabrication and Shipping

During the construction phase, all lumber needs to be protected from moisture effects due to rain and snow. This precaution will include moving the lumber indoors if precipitation is expected in weather forecasts.

The prefabricated panels, loose roof lumber, tools, and connections will be transported to USU in the ASCE trailer along with all the other ISWS competition projects. The trailer is typically packed full and meticulously organized to ensure that projects do not get broken or crushed. If the trailer is packed unevenly, there is a high chance that some or all projects will be negatively affected.

The lumber will be inspected upon purchase to ensure the material is of adequate quality. As lumber is the most expensive material for the project, damage or weathering of these products will negatively impact the budget and construction timelines.

If damage occurs to the structural components of the building during prefabrication, the team will allocate funds for repairs or make design changes, provided that these changes are implemented no later than seven days before the scheduled building day.

If damage occurs to the structure during transportation, the team will have time to make quick repairs before the competition begins if all the studs remain structurally stable.

1.5 Stakeholders

The NAU ASCE chapter is considered a stakeholder as the school expects the student group to perform well and positively represent their name. This representation may spark interest among other students and professionals to become involved within the school and student chapter.

The client, Mark Lamer, expects this contracted project to be of high quality and to outperform other TimberStrong teams at ISWS. As this year marks the first time TimberStrong is a CENE Capstone, the team is expected to set a high standard for the project in terms of technical work, project management, and results. These achievements will fulfill the client’s requirements, and justify the stake held by Mr. Lamer for this project and team.

Sponsors and donors hold significant financial and reputational stakes in the project. Their investments in the team are expected to yield successful results, reflecting positively on their involvement, and encouraging continued participation with future students, both within and outside of project teams.

2.0 Scope of Services

2.1 Task 1: Research

2.1.1 Task 1.1: Competition Rules

The purpose of this task is to determine and identify all competition rules and requirements. Parameters and design requirements from the TimberStrong Rules must be reviewed to gain an understanding of the project scope. These requirements include structural design parameters, project deliverables and tasks, and project report requirements.

2.1.2 Task 1.2: Material Research

The purpose of this task is to explore the materials that will be required to construct the structure. The materials required include timber, OSB sheathing, screws, and connector hardware. The team will review the softwood grading scale and factors that influence timber selection for projects.

2.1.3 Task 1.3: NDS and NDS Supplement

The purpose of this task is to gain an in-depth understanding of the NDS Supplement. The NDS Supplement will be consulted to determine the stress capacity design values and material properties of the chosen timber type and grade, as well as design value adjustment factors. The NDS will be consulted for the member design procedures, special design considerations, and the equations for flexural design, shear design, and deflection.

2.1.4 Task 1.4: SDPWS

The purpose of this task is to gain an in-depth understanding of the SDPWS. The SDPWS will be consulted for the lateral system design procedures for forces due to uplift, overturning, and shear. These procedures involve the diaphragm and shear wall designs for aspect ratios, panel configurations, shear wall design for the segmented and Force Transfer Around Opening (FTAO) methods, and unit shear capacities based on the panels and fasteners.

2.1.5 Task 1.5 MathCAD

The purpose of this task is for the team to become familiar with the MathCAD computer software that will be utilized for the structural calculations of the project. This familiarization will be attained through watching online tutorial videos and completing practice calculations.

2.2 Task 2: Preliminary Design

2.2.1 Task 2.1: Timber Selection

The purpose of this task is to review the possible types of timber that could be used in the structure to understand the advantages and disadvantages of each timber type. Timber types will be evaluated based on availability, price, and strength. These criteria will be utilized in a decision matrix to determine the best timber type for this project. Timber grades will be considered on a softwood scale due to the residential timber design scope of the project. This scope identifies the quality of timber that needs to be used in the framing of the structure. The quality of the timber corresponds to the strength and physical features of timber type which correlate with structural integrity.

2.2.2 Task 2.2: Initial Design Decisions

The purpose of this task is to create roof, floor, and wall framing plans for the initial structure. Design decisions for this process will include building footprint dimensions and the general placement of the roof ridge beam, roof joists, floor beams, wall studs, and window headers.

2.3 Task 3: Design and Analysis

2.3.1 Task 3.1: Determination of Gravity Loads

The purpose of this task is to determine the gravity loads applied to the structure. Live roof and floor loads will be found in the TimberStrong Rules. Dead loads will be calculated from the self-weight of the timber elements. The loads will be factored using ASD load combinations and applied to all design elements, which will be modeled as simply supported beams or vertical columns. The maximum shear, moment, and/or axial values for each beam or column will be calculated using engineering statics equations and concepts.

2.3.2 Task 3.2: Determination of Lateral Loads

The purpose of this task is to determine the lateral loads applied to the diaphragm, chord, collector, shear wall, and hardware elements. Roof wind uplift pressure, which can only be resisted by tie down straps (no dead load), and seismic distributed loads at the floor and roof diaphragms will be found in the TimberStrong Rules. Loads calculated within the system, such as the reaction of the diaphragms on the shear walls, will be determined and described within the lateral design steps of the related elements.

2.3.3 Task 3.3: Roof Design

2.3.3.1 Task 3.3.1: Roof Gravity Strength Design

The purpose of this task is to determine the necessary stress capacities and design the member sizes for flexure and shear. Stress capacities will be determined using the NDS Supplement for the chosen lumber type and grade. These values will be multiplied by any applicable adjustment factors from the NDS Supplement. The maximum shear and moment values determined in Task 3.1 using the factored applied loads will be used in flexure and shear stress equations. These equations will be set equivalent to the appropriate stress capacities to solve for the beam depth. The calculated depth will be compared to the assumed design depth; a successful result will produce a calculated depth that is less than the design depth, as this ensures the beam has sufficient capacity to carry the applied loads.

2.3.3.2 Task 3.3.2: Diaphragm Design

The purpose of this task is to design the roof diaphragm for the applicable seismic loading and internal stresses.

2.3.3.2.1 Task 3.3.2.1: Seismic Load and Internal Shear

The maximum unit shear values in the diaphragm will be determined from the applied factored seismic load described in Task 3.2 using engineering statics concepts.

2.3.3.2.2 Task 3.3.2.2: Design for Strength

The purpose of this task is to design the diaphragm for shear. Nominal unit shear capacities for blocked sheathed wood framed diaphragms will be determined using the SDPWS. These capacities will be divided by an ASD adjustment factor of 2.8 and multiplied by a specific gravity adjustment factor based on wood type. The unit shear value determined in Task 3.2.1.1 will be compared to the nominal unit shear found in the SDPWS for the designed panel thickness, nail size, nail length, and nail spacing of the diaphragm.

2.3.3.2.3 Task 3.3.2.3: Design for Serviceability

The purpose of this task is to check the deflections of the diaphragms to ensure they are within serviceability limits. The SDPWS diaphragm deflection equation will be utilized for this task. The calculated deflection story drift will be compared to the allowable story drift per ASCE 7-22.

2.3.3.3 Task 3.3.3: Chord Design

The purpose of this task is to design the chord, or the load-perpendicular diaphragm element, to resist the flexural force from the applied factored seismic diaphragm load.

2.3.3.3.1 Task 3.3.3.1: Seismic Load and Internal Compression

The purpose of this task is to determine the maximum moment in the chord due to the applied factored seismic load. This moment will be converted to stress on the member using the length and cross-sectional area of the chord.

2.3.3.3.2 Task 3.3.3.2: Design for Strength

The purpose of this task is to design the chord for bending. The capacity for the chord compression parallel to the wood grain will be determined using the NDS Supplement for the chosen lumber type and grade. This value will be multiplied by any applicable adjustment factors from the NDS and compared to the member stress.

2.3.3.3.3 Task 3.3.3.3: Design for Serviceability

The purpose of this task is to check the deflections of the chord to ensure they are within serviceability limits. The beam deflection equation will be utilized for this task. The calculated deflection will be compared to the AWC allowable beam deflection limits.

2.3.3.4 Task 3.3.4: Collector Design

The purpose of this task is to design the collector, or the load-parallel diaphragm element, to resist the shear force from the applied factored seismic diaphragm load.

2.3.3.4.1 Task 3.3.4.1: Seismic Load and Internal Shear

The purpose of this task is to determine the maximum shear in the collector due to the applied factored seismic load. This moment will be converted to stress on the member using the cross-sectional area of the collector.

2.3.3.4.2 Task 3.3.4.2: Design for Strength

The purpose of this task is to design the collector for shear. The shear capacity for stresses parallel to the wood grain will be determined using the NDS Supplement. This value will be multiplied by any applicable adjustment factors from the NDS and compared to the member stress.

2.3.3.5 Task 3.3.5: Rafter Tie-Down Design

The purpose of this task is to design the roof rafter tie-down hardware straps to resist the uplift wind load at the roof diaphragm.

2.3.3.5.1 Task 3.3.5.1: Wind Uplift Load

The purpose of this task is to use the roof wind uplift pressure, taken from the TimberStrong Rules, to determine the forces at the roof joist with the largest tributary width for conservatism.

2.3.3.5.2 Task 3.3.5.2: Design for Strength

The purpose of this task is to design the tie-downs by comparing the wind uplift design force to the allowable tie-down force capacity found in the appliable SST product manual.

2.3.4 Task 3.4: Wall Design

2.3.4.1 Task 3.4.1: Wall Gravity Strength Design

The purpose of this task is to design the wall framing member sizes and stud spacings for flexure and shear. The process described in Task 3.3.1 will be applied to the first story and second story wall designs.

2.3.4.2 Task 3.4.2: Wall Lateral Design

The purpose of this task is to design the lateral shear wall, hold-down, and anchor bolt elements for the first and second story walls.

2.3.4.2.1 Task 3.4.2.1: Shear Wall Design

The purpose of this task is to design the shear walls for the applicable factored seismic loading and internal stresses.

2.3.4.2.2 Task 3.4.2.2: Seismic Load and Internal Shear

The purpose of this task is to use the roof and floor diaphragm seismic loads, taken from the TimberStrong Rules, to determine the forces of the diaphragms on the shear walls as reactions. The maximum unit shear values for the shear walls will be determined from the applied factored seismic load at the diaphragms.

2.3.4.2.3 Task 3.4.2.3: Wall Design for Strength

The purpose of this task is to design the shear walls to resist the shear. The shear walls will be defined using segmented or FTAO shear wall methods. These methods will be completed using guidance in the SDPWS. The maximum unit shear value will be determined from the maximum shear produced by the applied factored seismic load, divided by the diaphragm length. This unit shear value will be compared to the nominal unit shear found in the SDPWS for the designed panel thickness, nail size, nail length, nail spacing of the shear wall.

2.3.4.2.4 Task 3.4.2.4: Wall Design for Serviceability

The purpose of this task is to check the deflections of the shear walls to ensure they are within serviceability limits. The SDPWS shear wall deflection equation will be utilized for this task. The calculated deflection story drift will be compared to the allowable story drift per ASCE 7-22.

2.3.4.3 Task 3.4.3: Hold-Down and Anchor Bolt Design

The purpose of this task is to design the shear wall hold-down hardware straps and anchor bolts to resist overturning due to the factored seismic load. Hold-down straps will be designed to connect the second story walls to the first story walls, and anchor bolts will be designed to connect the first story walls to the foundation.

2.3.4.3.1 Task 3.4.3.1: Overturning Force

The purpose of this task is to use the roof and floor diaphragm seismic loads, taken from the TimberStrong Rules, in a moment equation to determine the tension and compression forces at the ends of each shear wall.

2.3.4.3.2 Task 3.4.3.2: Design for Strength

The purpose of this task is to compare the overturing tension and compression forces at the shear wall ends to the allowable hold-down and anchor bolt force capacities found in the appliable SST product manuals.

2.3.5 Task 3.5: Floor Design

2.3.5.1 Task 3.5.1: Floor Gravity Strength Design

The purpose of this task is to design the floor framing member sizes and spacings for flexure and shear. The process described in Task 3.3.1 will be applied to the floor member size design.

2.3.5.2 Task 3.5.2: Cantilever Deflection

The purpose of this task is to calculate the predicted deflection of the cantilever due to a 150 lb point load for three loading locations. These locations are: 3'-6", 3'-9", and 4'-0" on the beam, measured from the exterior wall. The modeled beam will include the live floor loads and self-weight dead loads. The deflection will be calculated using the Method of Virtual Work, which utilizes real and virtual loads, internal moments, and section properties to predict deflection.

2.3.5.3 Task 3.5.3: Floor Lateral Design

The purpose of this task is to design the floor diaphragm for the applicable seismic loading and internal stresses. The processes described in Tasks 3.3.2 through 3.3.4 will be applied to the floor diaphragm, chord, and collector designs.

2.3.6 Task 3.6: Design Option Finalization

The purpose of this task is to finalize the structure designs. Once each element of the structure has been calculated and compared to the applicable capacities, any unsuccessful elements will be redesigned and recalculated. This iterative process will provide successful final structure designs that can be analyzed within a decision matrix.

2.3.7 Task 3.7: Decision Matrix

The purpose of this task is to create and utilize a decision matrix to apply to multiple structure designs. The criteria for this decision matrix will be based on maximizing points for the competition scores. Therefore, the criteria will include optimal budget due to the least amount of timber studs and sheathing, matching a Factor of Safety of 1.5 for the shear walls and diaphragms, and designing a cantilever deflection in the mid-range of 0.5-1.0 in.

2.3.8 Task 3.8: Final Design Selection and Hand Calculations

The purpose of this task is to select the final design based on the scoring of the decision matrix, then complete the hand calculations necessary for the TimberStrong report submittal. Hand calculations of every element of the structure will be completed based on the MathCAD worksheets following the finalization of the structure design. Utilizing the MathCAD software prior to hand calculations will optimize the use of the team's time and reduce errors that are likely to occur if all iterations of the design are only completed by hand.

2.4 Task 4: Modeling

2.4.1 Task 4.1: 2D Structural Drawings

The purpose of this task is to use Autodesk AutoCAD software to create two-dimensional structural drawings of the timber structure. The two-dimensional drawings will be utilized in the construction process of the project and a hardcopy of the drawings will be provided on Competition Day. The drawings will assist in showing the location of structural members and member dimensions.

2.4.2 Task 4.2: 3D Building Information Modeling

The purpose of this task is to use Autodesk Revit modeling software to create a three-dimensional model of the structure. Using Revit, a BIM model of the structure will be created to allow the team to assess how the multiple components of the structure will coordinate with each other. The BIM model will also allow for better communication between team members, sponsors, and advisors and assist in optimizing material use and lowering construction costs through manipulation of the design.

2.5 Task 5: Construction

2.5.1 Task 5.1: Material Acquirement and Prefabrication

The purpose of this task is to plan enough time to adequately acquire materials and prefabricate the structure sections. The materials must be acquired from local companies and be brought back to "The Farm" to cut. Connector hardware will be supplied from Simpson-Strong Tie as they are sponsoring the competition and will be donating the hardware to competition teams. Each piece of lumber for the structure will be precisely cut according to the design plans. The floor, roof and wall sections will be assembled, with sizing and placement confirmed before members are screwed together, to form the framing system. The sheathing for each section, excluding the roof, will then be fastened to the framed components. The entire prefabrication process will take three to seven days, depending on the number of available mentees to assist in construction.

2.5.2 Task 5.2: Construction Practice

The purpose of this task is to prepare for competition build day. The six competition builders will practice assembling the structure by marking the screw placement points for competition. These markers will serve a vital purpose as the holes cannot be placed in these specific areas until competition due to concerns about stripping. Instead, the practice holes will be placed directly above the screw locations to replicate the same actions required during the competition. Competition practice will last for approximately two hours.

2.6 Task 6: Competition

2.6.1 Task 6.1: Trailer Preparation and Transportation

The purpose of this task is for All ASCE student teams to prepare the trailer and personal items for transportation. Before packing the trailer with the necessary tools and projects, the inside must be thoroughly cleaned out. The arrangement of all projects and tools must be carefully planned to prevent any mixing up or breakage of projects, and to ensure that the trailer remains balanced and level for transportation. The trailer will be pulled by a truck for about 600 miles to USU and the student teams will ride together in school vans.

2.6.2 Task 6.2: Competition Build Day

The purpose of this task is to ensure the team understands all rules and requirements to obtain an adequate score in the competition build. The team captain must attend the captains meeting at USU the day before build day. This meeting will go over the rules and what to expect on build day.

The six competition builders will meticulously position each element within a 20-ft by 20-ft area. All required structure components and tools must be placed inside the designated building area before the competition begins. Once the competition starts, the team will have 90 minutes to complete the entire structure without any people or supplies entering or exiting the designated area. The team will pause after each floor to allow judges to assess structural stability.

2.7 Task 7: Investigate Project Impacts

The purpose of this task is to investigate the environmental impacts of the structure over time. Such impacts may include carbon footprint and sustainability. To ensure a neutral impact or better, the team will use environmentally friendly materials.

The purpose of this task is to evaluate the economic impact of constructing a small structure. An analysis of impacts will continually take place throughout the duration of the project. The acquirement of funds will impact the final design of the project.

The purpose of this task is to track the social impacts created by this project. The success or failure of this project may directly impact the NAU ASCE community as well as the general NAU student community.

2.8 Task 8: Project Deliverables

2.8.1 Task 8.1: Capstone Deliverables

2.8.1.1 Task 8.1.1: 30% Submittal

The purpose of this task is to ensure the student team is on track to complete final project and proposal in the scheduled timeframe. A report of roughly 30% completion will be submitted to the team's Grading Instructor by the deadline. This report will be accompanied by a presentation to be reviewed by peers and teaching advisors. The edits made from the comments on this first draft will allow the team to be on track to deliver a professional report. Tasks 1-3 should be completed by this point.

2.8.1.2 Task 8.1.2: 60% Submittal

The purpose of this task is to ensure the student team is on track to complete final project and proposal in the scheduled timeframe. A report of roughly 60% completion will be submitted to the team's Grading Instructor, by the deadline, along with a presentation to peers and teaching advisors. This report will serve as a second draft incorporating previous comments. The presentation of the report will allow for feedback to be given, ensuring that the team is on track to have a complete, professional report. Along with the tasks completed in the 30% report, Task 4 will be completed at this point.

2.8.1.3 Task 8.1.3: 90% Submittal

The purpose of this task is to ensure the student team is on track to complete the final project and proposal in the scheduled timeframe. A report of roughly 90% completion will be submitted to the team's Grading Instructor, by the deadline, along with a presentation to peers and teaching advisors. This report will serve as a third draft incorporating previous comments. The presentation of the report will allow for feedback to be given, ensuring that the team is on track to have a complete, professional report. Along with the tasks completed in the 60% report, tasks 5 and 8.2 will be completed at this point.

2.8.1.4 Task 8.1.4: Final Presentation

The purpose of this task is to present a concise and condensed version of the entirety of the project to the instructors of CENE 486 and NAU students. Every detail of the project will not be included, but the general process and results will be shown.

2.8.1.5 Task 8.1.5: Final Report and Website

The purpose of this task is to complete the professional documentation of the project in the form of the Final Report. This report will be updated with all edits from prior submittals. It will be submitted to the team's Grading Instructor by the deadline, with all project tasks completed.

The website will professionally display all the team's work from the project proposal to the final construction. The website will include each team member's contact information as well as any work completed throughout the duration of the project.

2.8.2 Task 8.2: Competition Deliverables

2.8.2.1 Task 8.2.1: Competition Registration and Compliance

The purpose of this task is to inform the competition judges that a student team from NAU will be participating during build day. The student team must submit an Intent and Eligibility Acknowledgement form no later than November 3rd at 5 pm. This form states the student ASCE chapter will have a team at competition as well as acknowledge the eligibility requirements for competition participation. The form must be uploaded to the Cerberus ftp server and be signed by the Team Captain, ASCE Student Chapter Faculty Advisor, ASCE Student Chapter President, and Competition Team Faculty Advisor.

Prior to any construction/assembly, the student team must also complete a free Ladder Safety Training course on stepladders through laddersafetytraining.org and complete a waiver form provided by ASCE. The certificate and form must be submitted to the Cerberus ftp Server.

2.8.2.2 Task 8.2.2: Final Project Report (Phase 1)

The purpose of this task is to document all of the team's work in one place. Phase 1 includes the project report that must be completed and uploaded in PDF form by January 26th. The report will meet all the competition rules and requirements.

By build day, the team must submit a copy of the report to the Cerberus ftp server, as well as provide the paper copies at competition.

2.8.2.3 Task 8.2.3: Structural Drawings & 3D Modeling (Phase 2)

The purpose of this task is to provide detailed drawing of the structure to the judges. Phase 2 includes the structural drawings, submitted in PDF format on a 22-in. by 34-in. sheet, a BIM model with the associated 3D graphics, and photos and/or videos of prefabrication. These files must be uploaded to the Cerberus ftp Server no later than February 23rd.

By build day, the team must submit the construction drawings to the Cerberus ftp server, as well as provide the paper copies at competition.

2.8.2.4 Task 8.2.4: Presentation (Phase 3)

The purpose of this task is to verbally explain the details of the project to the judges. Phase 3 includes the presentation materials and photos and videos of the team presentation. These items must be uploaded by March 1st to the Cerberus ftp Server.

2.8.2.5 Task 8.2.5: Final RFIs and Change Orders

The purpose of this task is to ask the judges clarifying questions and inform them of any changes to the initial design. The team must submit any final questions through an RFI 14 days prior to build day. The FRI is to be sent to student@asce.org with the subject line "TSDB Competition RFI" and the final clarifications will be posted to the Timber-Strong Design Build Competition Collaborate Site every other Friday starting September 29th.

Change orders must be submitted a minimum of seven days prior to building day. This includes changes to any of the previous phase submissions. Change orders cannot be used to revise completed drawing sets.

2.8.2.6 Task 8.2.6: Visual Aid

The purpose of this task is to summarize the details of the project on a single poster. On build day, the team must display a visual aid 30 in. tall by 40 in. wide on an easel of a 60 in. or taller at the building site. The visual aid must include drawings, graphics, text, and photos that summarize and illustrate the significant aspects of the project. The visual aid must meet all of the competition rules and requirements.

By build day, the team must submit the visual aid to the Cerberus ftp server.

2.9 Task 9: Project Management

2.9.1 Task 9.1: Resource Management

The purpose of this task is to keep track of the project budget and staffing. The initial budget will be estimated based on previous designs, then reviewed and updated as the project and design develop. Staffing will include logging hours worked on project tasks. Resources shall be tracked to ensure that the spending does not exceed the allotted budget based on sponsorship donations.

2.9.2 Task 9.2: Schedule Management

The purpose of this task is to keep the team on schedule for a successful project. All scheduling will be completed by the team through project scheduling software. The team will organize all submittal dates through a Gantt chart and organize all meetings a week before through Google Calendar. The scheduling software will also be used for budget tracking in terms of the billing hours.

2.9.3 Task 9.3: Meetings

The purpose of this task is to provide records of all meetings. All meetings will have a meeting agenda created and sent to all individuals invited to the meeting. Detailed meeting minutes will be taken during the meeting and sent out no later than three days after the meeting occurs.

2.9.3.1 Task 9.3.1: Team Meetings

The purpose of this task is to ensure progress on deliverables is being made, and there is equal contribution to all aspects of the project. Team meetings will occur a minimum of twice a week with required attendance from all team members.

2.9.3.2 Task 9.3.2: Mentee Meetings

The purpose of this task is to teach mentees the different aspects of the project, as well as obtain assistance on tasks, Mentee meetings will occur a minimum of once a week. During these meetings, mentees will be assigned tasks or be taught about different aspects of the competition. If mentees do not show up, these meeting times will be used for completion of upcoming deliverables.

2.9.3.3 Task 9.3.3: Client Meetings

The purpose of this task is to update the client on the project process. The team will meet with the client a minimum of once a month to discuss project process and expectations.

2.9.3.4 Task 9.3.4: Technical Advisor Meetings

The purpose of this task is to obtain technical guidance each semester. Technical Advisor meetings must meet a minimum of six times with two occurring in Fall 2023 and the other four to be completed in Spring 2024.

2.9.3.5 Task 9.3.5: Grading Instructor Meetings

The purpose of this task is to obtain critical feedback on what is expected of the team. Grading Instructor meetings will occur a minimum of six times, requiring two of which to be completed in Fall 2023 and the other four to be completed in Spring 2024.

2.10 Exclusions

The management scope for this project does not include the completion of the ASCE Student Chapter Report and Dues that are required for ISWS competitions. These tasks will be completed by the NAU ASCE Student Chapter Officers.

The construction scope for this project does not include drilling the designed anchor bolts into a concrete foundation during the ISWS competition. The anchor bolts will be properly designed and included in the budget but will not be physically used in construction.

6.0 References

[1] "Best Places to Live," [Online]. Available: bestplaces.net/city. [Accessed 01 10 2023].

[2] "Flagstaff Arizona Map," Arizona Vacation, [Online]. Available: https://www.arizona-leisure.com/flagstaff-area-map.html. [Accessed 01 10 2023].

[3] American Wood Council, Special Design Provisions for Wind and Seismic, Leesburg: American Wood Council, 2021.

[4] American Wood Council, National Design Specifications, Leesburg: American Wood Council, 2018.

[5] "Importance of Selecting Proper Connectors and Fasteners for a Continuous Load Path," [Online]. Available: https://mypdh.engineer/lessons/4-importance-of-selecting-proper-connectors-and-fasteners-for-a-continuous-load-path/. [Accessed 3 October 2023].

[6] "Type of Lumber: Hem Fir," Lampert Lumber, [Online]. Available: https://www.lampertlumber.com/hardware-store-products/lumber/types-of-lumber/hem-fir/. [Accessed 3 October 2023].

[7] "Lumber Grades Explained," Thomas Publishing Company, [Online]. Available: https://www.thomasnet.com/articles/plant-facility-equipment/lumber-grades/. [Accessed 3 October 2023].

[8] "Google Earth," Google Earth, [Online]. Available: earth.google.com. [Accessed 23 September 2023].

[9] A. S. o. C. Engineers, *TIMBER-STRONG DESIGN BUILD,* 2023.

[10] WoodWorks, "WoodWorks Carbon Calculator," WoodWorks Wood Product Council, 2023. [Online]. Available: https://www.woodworks.org/resources/woodworks-carbon-calculator/. [Accessed 27 September 2023].

APPENDICIES

APPENDIX A: OFFICIAL DESIGN CONSTRAINTS

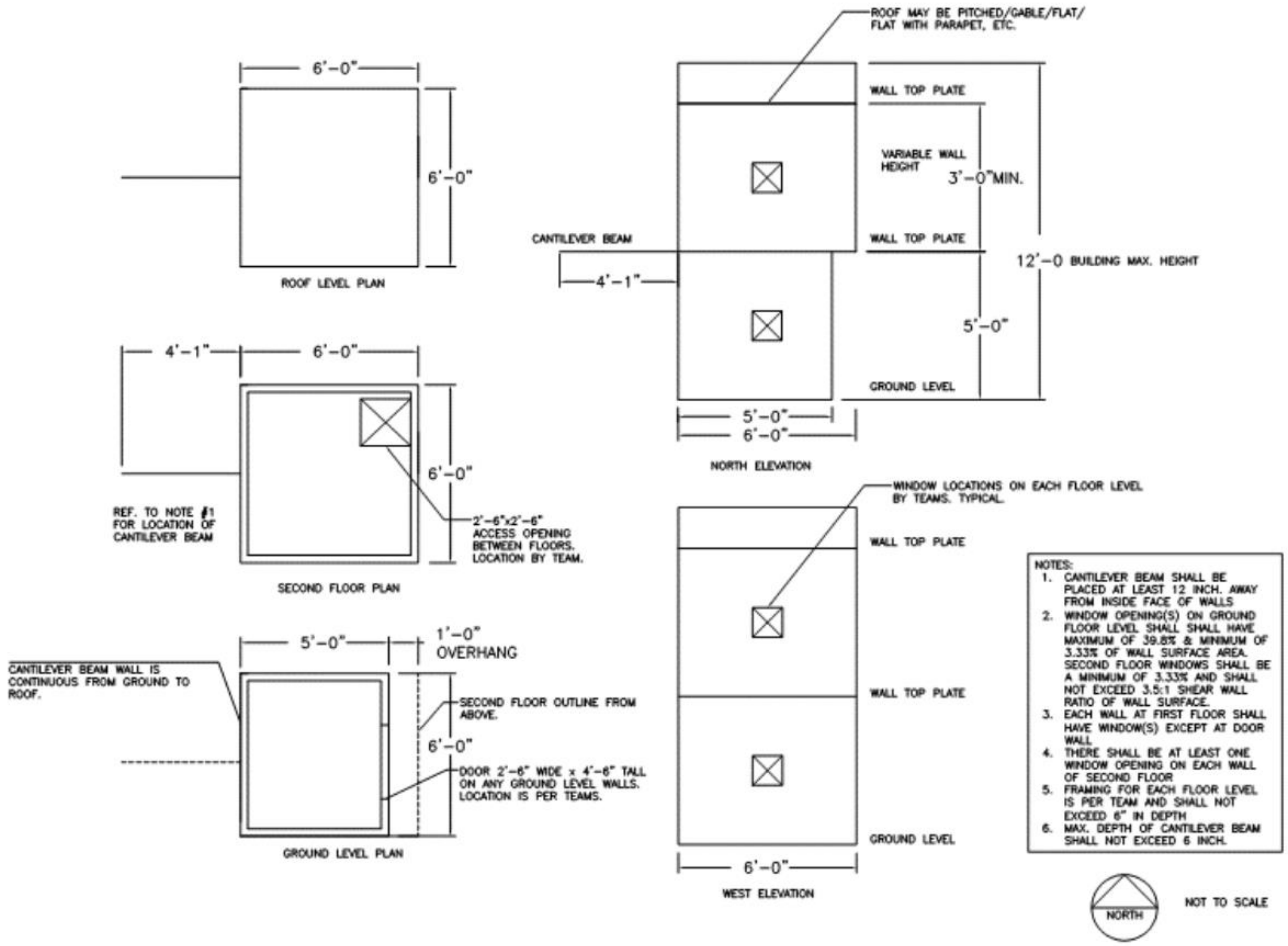

Figure A- 1: Design Constraints