Student Steel Bridge Capstone

Ponderosa Steel Jacks

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Final Proposal

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1.0 Project Understanding

1.1 Project Purpose

Steel Jacks aims to design a 1.25-mile steel bridge for Lincoln Parish Park in Ruston, Louisiana. The bridge will provide a connection across a small portion of the body of water in the park to allow for more efficient travel throughout the park without obstructing the future development of the disc golf course. The bridge design will need to be versatile and match the aesthetics of the park environment. Prior to the installation of the bridge, the goal of this project is to create a 1:10 scale model of the steel bridge. The scale model will be used to ensure the future bridge can withstand the anticipated load requirements. The result of this project will yield a design that will be implemented in the park.

1.2 Project Background

The scale model of the bridge will be used as a reference for bridge construction in Ruston, Louisiana. The bridge will be located over the lake at Hideaway Park Disc Golf Course, owned by Louisiana Tech University, which will be adjacent to the future section of the course. Figure 1-1 shows the location within Louisiana. Figure 1-2 shows the vicinity map of the project.

Figure 1-1: Project Location Map [1]

Figure 1-2: Project Vicinity Map [2]

1.3 Technical Considerations

The process for finalizing the truss design will entail a systematic approach which can be referenced in Figure 1-3.

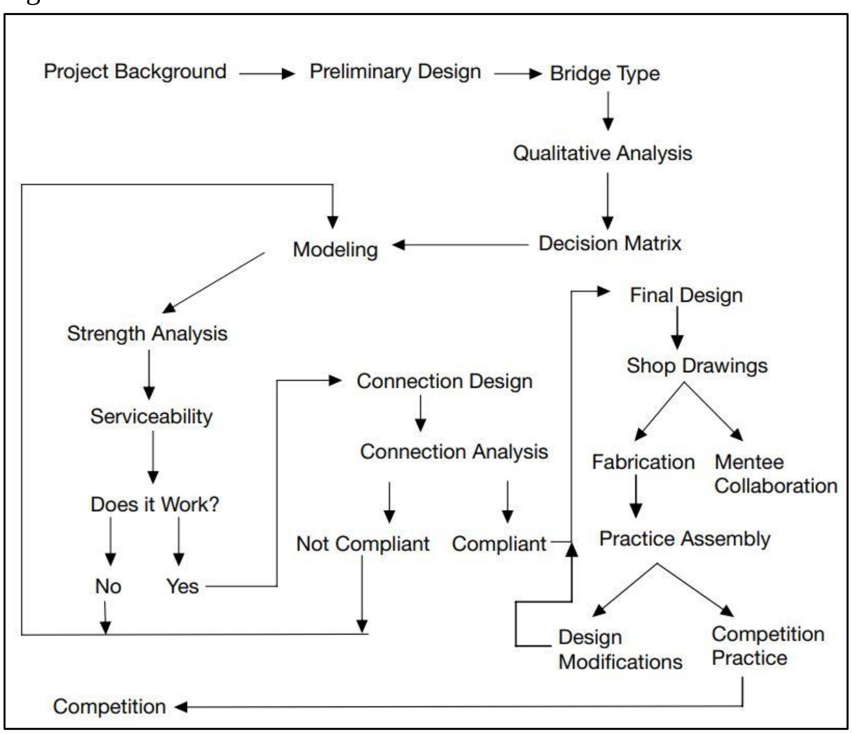


Figure 1-3: Project Design Flow

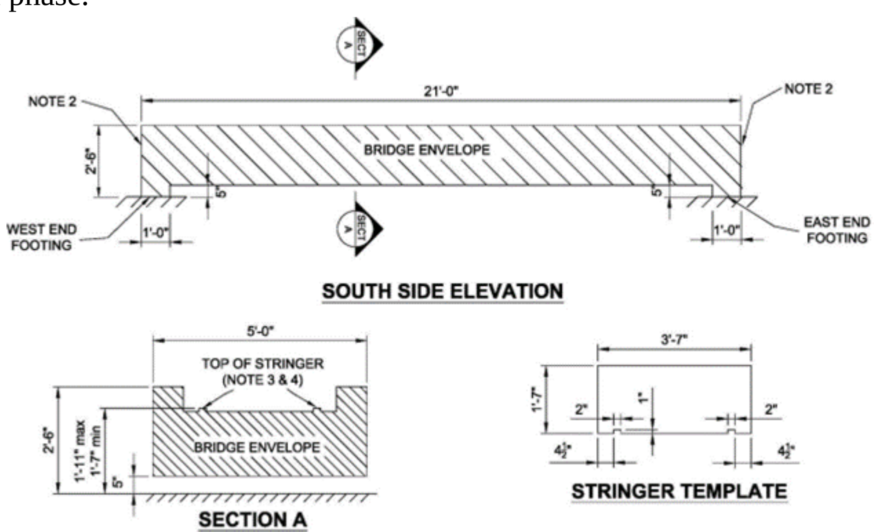
In the initial stages, hand calculations for the entire truss system will be done using the method of joints, method of sections, method of virtual work, and force method of trusses. These types of calculations will be required to determine the internal forces within the truss. Using the internal forces of each member, the required cross-sectional area of the member can be estimated. Additionally, hand calculations will be needed to determine which members of the truss are in tension and compression based on load combinations. All calculations for the internal stress and connection stress of each member must be compliant with the American Institute of Steel Construction Thirteenth Edition (AISC-13) code capacities. To optimize construction speed, each individual member will need to be fabricated to allow for ease of attachment via the determined connection type. Fabrication tolerances will be considered when designing each connection.

1.4 Constraints and Potential Challenges

1.4.1 Constraints Overview

1.4.1.1 Dimension Constraints

The dimension constraints are based on the scale model requirements, as specified in the AISC rule book. The bridge will need to fit within the dimensional limits shown in Figure 1-4 [3]. The four footings of the bridge as well must fit within a 1ft x 1ft area. The footings of the bridge may not go outside the boundaries at any point during or after the construction phase.



Notes:

1. DRAWINGS ARE NOT TO SCALE
2. NO PART OF THE BRIDGE SHALL EXTEND AWAY FROM THE RIVER BEYOND THE CONSTRUCTION ZONE BOUNDARIES
3. TOPS OF STRINGERS SHALL BE AT LEAST 20 FT. LONG AND AT MOST 21 FT. LONG
4. BRIDGE SHALL PROVIDE STRAIGHT, CLEAR DECKING SUPPORT LOCATION AND PASSAGE WAY

Figure 1-4: Bridge Dimensions [3]

1.4.1.2 Material Constraints

The materials are required to be all magnetic steel. Specific types of steel can vary. The materials must all be commercially available per regulations. If the team decides to use material not specified, the bridge will not be eligible for awards.

1.4.1.3 Construction Regulations

During the mock construction, there will be a designated 30-min time allotted to construct the bridge. Due to the bridge being located above a lake, there will be a temporary barge installed to allowing the bridge to be connected along either side. Construction team members termed as “bargers” will begin the construction phase on the dock. Bargers are not permitted to walk through the river but may reach over the river to hand-off beams between other non-bargers. The river boundary can be seen in Figure 1-4. The construction will begin with footing placement, then all subsequent members attached will be placed with the appropriate connections. All connection will be fastened and inspected for completion. [3]

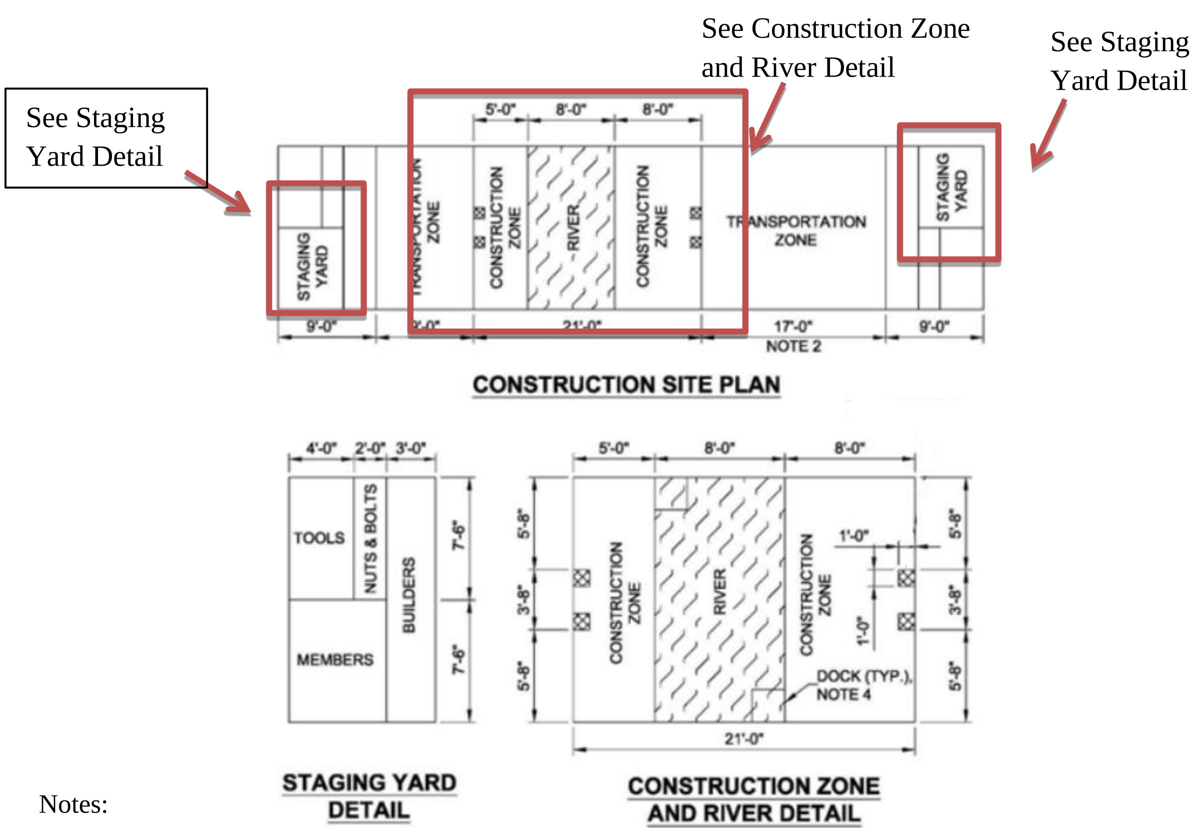


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Figure 1-5: Construction Site Plan [3]

1.4.1.4 Loading Requirements

The bridge will need to be able to support load based on a lateral and vertical load test. The lateral test requires a 75lb pre-load on one side of the bridge prior to the 50lb laterally applied load to the opposing side of the pre-weight. The vertical load test requires the bridge to support two sections of decking with an additional 100 lbs of preload. After the preload is applied to both portions of decking, there will be 1400 lbs of load added to one section of decking, and 900 lbs to the opposing section of decking. The measurements of the placement for all loads will be dependent on a randomized roll at the beginning of the competition using predetermined locations. Figures below show the critical sections on the bridge where Figure 1-6 identifies the potential load placement on the bridge, Figure 1-7 identifies the vertical load test and how the placement of load will be determined, and Figure 1-8 describes the lateral load placement on the bridge [3].

N	L1	L2	S
1	4'-6"	9'-0"	7'-6"
2	6'-0"	12'-0"	9'-0"
3	7'-0"	13'-0"	9'-0"
4	7'-6"	11'-6"	9'-0"
5	8'-6"	12'-6"	10'-6"
6	10'-0"	14'-0"	10'-6"

Figure 1-6: Load Placement Dimensions [3]

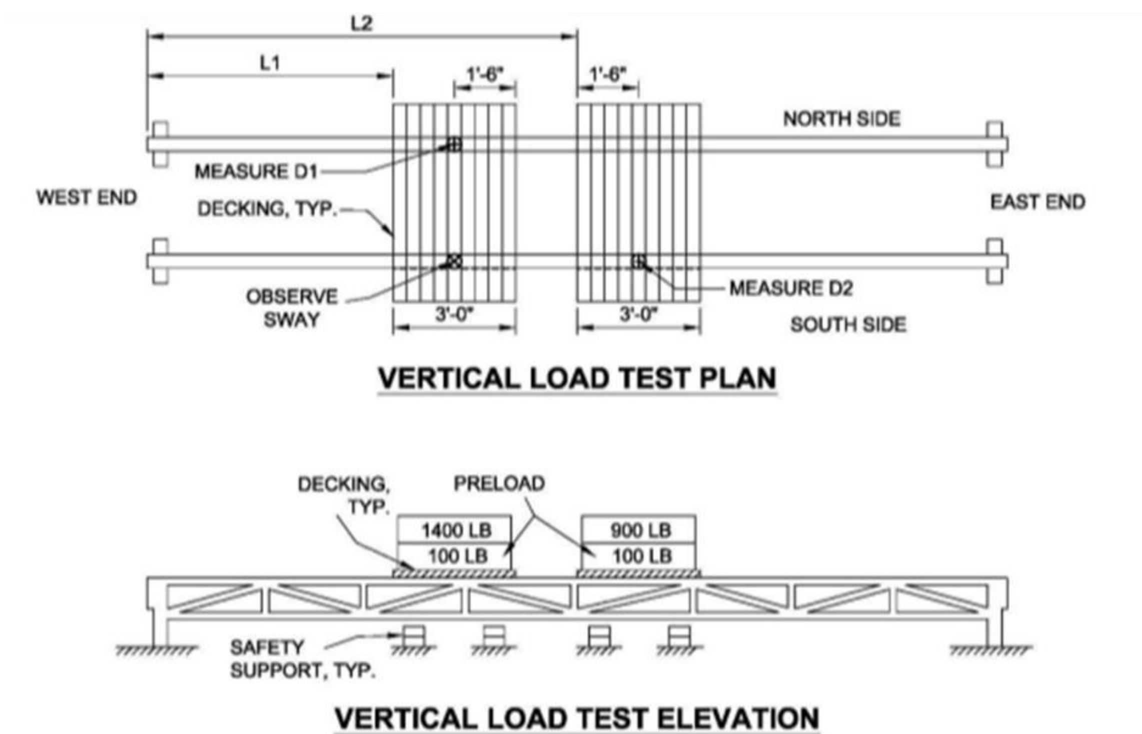
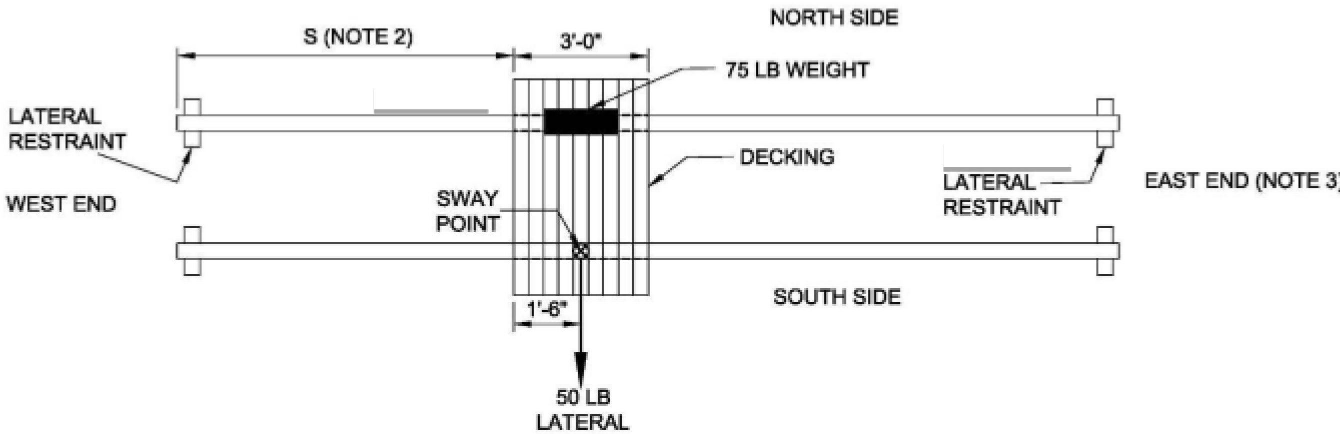


Figure 1-7: Vertical Load Profile View [3]



Notes:

1. DRAWINGS ARE NOT TO SCALE
2. DECKING LOCATION “S” IS DETERMINED BASED ON THE DIE ROLL AND IS THE SAME FOR ALL BRIDGES.
3. EAST END OF THE BRIDGE IS DETERMINED BASED ON A RANDOMIZING PROCESS FOR EACH BRIDGE.

Figure 1-8: Lateral Load Plan View [3]

1.4.2 Potential Challenges

1.4.2.1 Cost

The cost of this project could have the potential to go over budget. To prevent going over budget, the team will take actions to get sponsors, as well as getting material donations. In previous years Page Steel has donated steel to the NAU steel bridge team in which this steel would be the primary material for construction. Under the circumstances sponsors are not acquired to fund the project there is a $750 stipend given to the team from AISC SSBC foundation. This stipend will be used primarily to acquire and transport materials assuming no sponsors can be obtained. A fabricator has graciously donated their time to fabricate the bridge members and connections for the project assuming proper lead time is given in advance.

1.4.2.2 Time

The ability to manage the project’s timeline could be a potential challenge. To construct the scale model of the bridge, steel will need to be shipped from the distributor and be fabricated to meet design specifications. The initial meeting with the client stressed the importance of allowing enough lead time to get all the members fabricated before the end of the project timeline. To prevent this issue from occurring, the team will arrange a schedule to accommodate the expected lead time of steel distribution and fabrication. An initial meeting with the client was held in which they explain the expected lead time for obtaining the steel from the distributor would be between 2-3 weeks and fabrication would be upwards of two weeks. To mitigate these delays the team plays to have shop drawings done over 5 months in advance to account for fabrication and distribution delays.

1.5 Stakeholders

Stakeholders are businesses, organizations, and investors who will ultimately be affected by the implementation of the proposed design. For this project, the stakeholders are Louisiana Tech University, Hideaway Park Disc Golf Course, ASCE, NAU, and Mark Lamer.

The investors for the steel bridge design are ASCE, NAU, and the client, Mark Lamer. These associations and individuals all have a stake in the project due to their investment of time, money, or donations meant to fund the construction and materials. Locations that have stake in the project are Louisiana Tech University and Hideaway Park Disc Golf Course. They have a stake in the project because the bridge will eventually be constructed at these locations.

2.0 Scope of Services

2.1 Task 1: Project Background Research

2.1.1 Task 1.1 Competition Details

The purpose of this task is to determine the competition location, schedule and resources provided by the host school during competition.

2.1.2 Task 1.2 Material Availability

The purpose of this task is to conduct research on the types of potential types of steel that can be used for our design while maintaining compliance with AISC rules. The team will conduct comprehensive research on a range of various materials and document tensile strength, ultimate strength, modulus elasticity, and other significant material specifications. This research will also include determining the available cross-sections of steel that can be obtained from suppliers. This research will ensure that the most optimal material for the fabrication of the steel bridge.

2.1.3 Task 1.3 Research Connections

The purpose of this task is to conduct research on potential connection types that may be used, as defined by AISC Student Steel Bridge Competition (SSBC) rules. Additional research will be conducted to determine allowable connection types using ANSI/AISC 360.

The research will include investigating the various commercially available connection types and noting their various advantages and disadvantages. Potential considerations for connection designs will include dimensions, ease of fabrication, ease of construction and total retail price.

2.1.4 Task 1.4 Truss Design Ideas

The purpose of this task is to conduct research on various structural designs that include traditional and innovative approaches. The research will involve the assessment of the aesthetics, constructability, stiffness, and weight of the structure. General qualitative analysis will be done to determine the advantages and disadvantages of each structure type. Research will also be conducted on designs that had previously won the AISC SSBC. The results of this research will aid in designing a bridge that limits vertical and lateral deflection in the least amount of construction time.

The team will create preliminary designs that will be analyzed to determine the estimated vertical and lateral deflection. After the vertical and lateral deflections have been estimated each design will determine the anticipated number of connections that will be required for the design. By determining the number of pin connections needed, it will allow the team to evaluate the constructability of the bridge with consideration for competition requirements. All the research will be compiled and compared with the preliminary designs to develop a design matrix for the final design.

2.2 Task 2: Preliminary Analysis and Design

2.2.1 Task 2.1 Structure Configuration

The purpose of this task is to analyze each preliminary design to determine the internal forces of each member, the maximum lateral and vertical deflections, and the overall performance of the bridge. Based on the information obtained from Task 1.4 general qualitative analysis will be done comparing the constructability, aesthetics, stiffness, and weight of the preliminary designs. Upon determining a design in which the team believes best satisfies the design criteria, initial analysis will be conducted considering the dead and live load criteria listed in the AISC competition rules. Basic statics analysis will be done to determine which members are in compression and tension. The analysis will also determine members undergoing high loads and adjustments will be made to determine the optimum cross section for each member. The relative weight of each design will be estimated. With the determination of internal forces of each member, analysis using the “Method of Virtual Work” will be conducted to determine the deflection measured primarily at the center of the truss system to determine the max deflection that can be anticipated.

Another element of the design process is to take into consideration the capacity of the connections. Analysis will be conducted on the connections to determine shear, tensile, and compression capacities in accordance with AISC-13. This analysis will operate under the assumption that all connection will be made perfectly with no faults. This assumes that each connection will not produce any slop so and all analysis will be done assuming ideal conditions. This is assumption is done solely during the preliminary design as to quickly identify the integrity of the structure and connections.

2.2.2 Task 2.2 Material Specifications

The purpose of this task is to analyze various materials that were chosen based on research conducted in Task 1.2. Simple mechanics of materials analysis will be conducted to determine the maximum tensile and compression strength of each cross section of each material. Upon completion of the analysis the chosen material will be put into a material exclusive decision matrix to determine the optimal material.

2.2.3 Task 2.3 Connection Design

The purpose of this task is to begin quantitative analysis of the connection types chosen from Task 1.3. Analysis will then be done following the criteria identified in Task 1.3. Upon completion of this analysis, the results will be compiled into a connections exclusive decision matrix.

2.2.4 Task 2.4 Design Matrix

The purpose of this task is to develop a final bridge design that will be effective and efficient. A design matrix generated guide the design process for the most ideal bridge. The matrix will include load application, stiffness, constructability, weight, cost, and aesthetics. To create the most optimize design, a weight was given to each category depending on the importance the team perceived each attribute with attention focused on elements that have weight in the competition. The preliminary designs will analyze the various members and material options and a final design will be generated.

2.3 Task 3: Final Analysis and Design

2.3.1 Task 3.1 Design Modeling

The purpose of this task is to begin modeling the final design determine from Task 2.4. The modeling for the project will begin by creating a 3D model of the bridge. Upon completing this 3D model different load cases and load combinations will be entered into the program to simulate different loading conditions as listed from the AISC SSBC rules. The locations of these loadings can be seen in Figure 1-5, Figure 1-6, and Figure 1-7. The load combinations will produce the internal forces of each member which will visually show the overall strength of the structure. The team will then analyze any weak points on the structure and adjust the design as necessary to improve the serviceability of the structure.

2.3.2 Task 3.2 Strength Analysis and Design

The purpose of this task is to determine the internal forces in each member as well as the total vertical and lateral deflection of the bridge. These internal member forces will be compared with the capacities found in the AISC-13 code book and ensure the final design will stay within the limits of competition. Following the AISC SSBC rulebook the final design will not exceed a vertical deflection of 2 inches and ¾ inch in the lateral deflection. Using this analysis method, it will aid in optimizing the final bridge design. The team will conduct analysis on a few individual critical members and code check these by hand. After confirming these members are compliant and cross referencing the member in RISA 3D, the team will be able to use RISA 3D to code check the remaining members. Additionally, a P-delta analysis will be set up within RISA 3D to identify lateral deflection.

2.3.3 Task 3.3 Serviceability Analysis and Design

The purpose of this task is to analyze the deflections that will occur in the beam using RISA 3D. The team will input deflection values into RISA 3D. The deflection values will be the limit for which the bridge should deflect to. To account for the slop due to fabrication imperfections the team anticipates using half the vertical deflection value given by the AISC rule book as advised by the team's technical advisor. Alongside measuring the vertical deflection, the team will use P-delta analysis in RISA 3D to measure the anticipated horizontal deflection. This deflection limitation will remain the same as what is listed in AISC rulebook.

2.3.4 Task 3.4 Connection Analysis and Design

The purpose of this task is to individually analyze each connection at each joint of the entire truss system. The analysis of each connection will vary dependent on the adjustments made to the connection point from Tasks 3.1 and 3.2.

2.4 Task 4: Bridge Production

2.4.1 Task 4.1 Shop Drawings

The purpose of this task is to create shop drawings for individual members and pieces of the bridge that will be made once the final design meets competition expectations. All shop drawings are to be made in AutoCAD following detail specifications requested by fabricators. Coordination with fabricators to confirm the direction of the build and how it will be constructed will be relayed to ensure all members and the method of assembly is described and labeled after fabrication.

2.4.2 Task 4.2 Fabrication Coordination

The purpose of this task is to communicate with steel donors and professional fabricators to fabricate the members and connections necessary for the success of the project in a timely manner. Shop drawings will be provided to the fabricator with confirmation of all required information pertaining to the bridge design. All material will be provided to the fabricator with a confirmed vendor, and the team will coordinate steel procurement for the fabricator.

2.4.3 Task 4.3 Mentee Collaboration

The purpose of this task is to make sure mentees are recruited prior to conference. With team participation in the Steel Bridge Club on campus, team members will be charged with recruiting and organizing events with students. Mentees will be given opportunities to participate and analyze the design process the team will undergo. Additionally, the mentees will be selected to participate in the construction of the bridge at competition. Mentees who attend will be required to meet and participate in practice.

2.5 Task 5: Assembly

2.5.1 Task 5.1 Conduct Initial Assembly of Members

The purpose of this task is to collect all members and parts to begin initial construction and coordination. Then the process of labeling and identifying members/connections will be completed, as it is imperative all members are confirmed to connect with associative bolts. This will help finish the overall bridge and the connections allowing for any design errors to be identified.

2.5.2 Task 5.2 Design Modifications

The purpose of this task is to inspect and confirm all members from fabrication are accurate. Members that do not pass inspection will need to be redone, and new fabrication of the members will need to be requested. A meeting will be set up with the project manager for the vendor to confirm the details of the assemblies and redlined notation of issues with product.

2.5.3 Task 5.3 Practice Assembly Prior to Competition

The purpose of this task is to complete all designs, fabrications, and modifications to begin assembly of the final design. With confirmed assembly process, the members will be given a final labeling system to promote organization with construction. As the competition requires a strict set of construction rules and regulations, the team will work to perfect the construction of the bridge. The team will work to practice until the bridge can be constructed with the 30-min allotted time. Additional practice will be conducted to optimize construction speed, minimize errors, and reduce accidents. The team will enlist the help of mentees to ensure that the members are assembled efficiently prior to competition.

2.6 Task 6: Competition

The purpose of this task is to gather all pieces, members, and connections to be transported to the location of the 2024 competition. From there, the bridge design will be assembled in accordance with the steel bridge rule book and judged for functionality, aesthetics, and load application [3]. A poster will be created summarizing the bridge design process, along with a completed construction of the bridge.

2.7 Task 7: Project Deliverables

2.7.1 Task 7.1 30 Percent Deliverable

The purpose of this task is to complete the 30% deliverable which contains the completed project understanding, research pertaining to the competition, and parameters of the competition. Additional design research shall be completed in order to establish a clear decision matrix. Tasks that will be included in this deliverable will be Task 1 and all associative subtasks.

2.7.2 Task 7.2 60 Percent Deliverable

The purpose of this task is to complete the 60% deliverable which includes a program-rendered model of the design of choice, in addition to the shop drawings. Hand calculations for the design shall also be complete for this deliverable and organized in the appendix, with the addition of a discussion regarding the calculations. Tasks that will be included in this deliverable will include Task 2, Task 3 and all associative subtasks.

2.7.3 Task 7.3 90 Percent Deliverable

The purpose of this task is to complete the 90% deliverable which contains the completed fabrication of the model bridge and indicates that the bridge is ready to be sent to the competition. Additionally, the calculations for loading, stress, and strain must be provided. The significance of this deliverable is to serve as quality assurance for the final deliverable. Tasks that will be included in this task will be Task 4, Task 5, Task 6, and all associative subtasks.

2.7.4 Task 7.4 Final Report

The purpose of this task is to complete a final report which includes the entirety of the design process, as well as the analysis and results. This is meant to gather all the team's design work into one professionally formatted report which can be navigated with ease and a team website that includes all portions of the project. Additionally, an appendix with calculations must be included to support the conclusion.

2.7.5 Task 7.5 Project Website

The purpose of this task is to construct a website for our final design and proposal. The website will be designed to compile all the data used for the analysis.

2.7.6 Task 7.6 Final Presentation

The purpose of this task is to prepare a final design proposal presentation that clearly establishes the design process and the final bridge design. This is significant for communication with the stakeholders and updates them with the design. It will clarify any adjustments that were made in the schedule of the project.

2.8 Task 8: Project Management

2.8.1 Task 8.1 Schedule Management

The purpose of this task is to assign tasks done by the project manager and an estimated time will be allotted for each individual task. Each task will be given a due date in which a task will need to be completed. It is the responsibility of the project manager and team members to coordinate additional resources when necessary. The schedule is important to efficiently manage task time throughout the project and ensure the team functions as efficiently as possible.

2.8.2 Task 8.2 Resource Management

The purpose of this task is to coordinate with team members to determine what resources may be required for specific tasks listed out in the schedule. It is the responsibility of individual team members to determine what resources are necessary for the task they have been assigned. To accomplish this, a general team consensus on current outstanding tasks will be regularly established. Based on the task assigned to individual team members, specific equipment and materials may be utilized by both the team and fabricators if necessary. Overseeing the budget of the project with individual staff rate breakdown and the cost of engineering services will be required to efficiently manage the available resources.

2.8.3 Task 8.3 Meetings

2.8.3.1 Task 8.3.1 Client Meetings

The purpose of this task is to provide the client with bi-weekly meetings at a minimum for the initial design process with a final meeting to discuss the design. Additional meetings will be held before and after procurement of materials. Alongside this, meetings will be held with the client upon completion of each fabrication review to update the client on the timeline of fabrication. Additional meetings will be set up after each practice assembly to update the client on the outcome of the assembly.

2.8.3.2 Task 8.3.2 Technical Advisor Meetings

The purpose of this task is to consult with the technical advisor through each stage of the design process. Based on the design phases listed through each task a minimum of 5 meetings will need to be conducted however the team is expecting this number to reach closer to 10-15 as many of the meetings will be going over RISA 3D modeling, checking, and instruction. The technical advisor will assist with the design process and understanding of software and construction. The advisor will help with understanding elements of the project relating to calculations and final implementation to shop drawings.

2.8.3.3 Task 8.3.3 Grading Instructor Meetings

The purpose of this task is to consult with the grading instructor to confirm and improve deliverables including 30, 60, 90, and the Final. The team anticipates meeting with the instructor at least once before each submittal to go over any questions in regard to feedback received.

2.9 Task 9 Impact Analysis

The purpose of this task will be to assess the positive and negative environmental, social, and economic impacts of the project.

2.10 Exclusions

The exclusions of this project are anchored footings, Life Cycle Cost Analysis (LCCA), AutoCAD rendering, full scale design of the bridge, and full set of drawings.

3.0 Schedule

3.1 Discussion of Schedule Logic

In the teams' project schedule, the project has been broken down into a comprehensive project timeline that encompasses the projects total duration, major tasks, and deliverables. The projected duration of the project spans a total of 170 days. The major tasks that are integrated into the project schedule encompass all of the tasks in Section 2. The main milestones have been outlined showing design analysis, modeling, assembly, and competition as some of the major milestones in the project. Another milestone is the project deliverables, including the 30%, 60%, and 90% submittals, along with the final draft and final presentation. The project schedule can be seen in Appendix A.

3.2 Critical Path

The critical path for the projects schedule has also been identified. The critical path is the longest sequence of tasks that, if delayed, the completion date of the project will also be delayed. For this reason, it is crucial that the team identified the critical path to ensure the project gets completed on time. In order to ensure that the critical path was not delayed, the team will allocate resources efficiently, prioritize tasks, and hold regular team meetings as identified in the project management task section.

4.0 Staffing

4.1 Staff Positions

The project includes 4 staff positions including Senior Engineer (SENG), Engineer (ENG), Shop Technician (TECH), and Drafter (DRFT). A summary of all positions can be found in Table 4–1 below.

Table 4 - 1 : Summary of Staff Positions

Abbreviation	**Position**
SENG	Senior Engineer
ENG	Engineer
TECH	Shop Technician
DRFT	Drafter

4.2 Qualifications and Responsibilities

4.2.1 Senior Engineer

The Senior Engineer for the project has a decade of experience working on different civil and structural engineering projects. Additionally, the Senior Engineer possesses both a Professional Engineering (PE) and Structural Engineering (SE) license. The Senior Engineer will be responsible for scheduling, reporting, and presenting the project. To ensure the quality of the project the Senior Engineer will provide oversight on the engineer's tasks and preparation for competition. The Senior Engineer will also be responsible for confirming the finalized report and in charge of presenting the project to the client alongside the team. Lastly the Senior Engineer will be the designated Engineer of Record (EOR) for the project.

4.2.2 Engineer

The Engineer has accumulated 3 years of experience in design and drafting for structural projects to be qualified for the position. The Engineer for the project possesses both PE and SE licensure. The Engineer will be responsible for the technical work of the project. The technical work the Engineer will be responsible for includes design, analysis, and modeling of the project. While completing the technical work, the Engineer may assign tasks to the Shop Technician and Drafter. When assigning tasks, the Engineer will oversee the work assigned to these two positions and ensure the quality of the work completed. The Engineer will also be responsible for creating preliminary shop drawings for the Drafter and Technician to use as reference.

4.2.3 Shop Technician

The Shop Technician has accumulated 5 years of experience working with the shop's welders and fabricators. The Shop Technician is responsible for working with the Engineer to produce a set of shop drawings, along with communicating the design to the fabricators. The Technician will be responsible for collaborating with fabricators to ensure all design details and any modifications are resolved. Additionally, they will be responsible for inspecting the fabricated materials and recommending any necessary design modifications. The Shop Technician will work closely with the Engineer to confirm the design with an initial and final assembly of all members. The Shop Technician will also work with the Drafter to confirm all details and labeling necessary are included in the shop drawings.

4.2.4 Drafter

The Drafter has accumulated over 2 years of experience drafting for several civil and structural engineering projects, along with exceptional experience and knowledge in computer-aided drafting. The Drafter will primarily be responsible for creating the shop drawings that are needed by the Shop Technician. Additional responsibilities may be given to the Drafter by the Engineer including modeling designed structures.

4.3 Staffing Table

All tasks found in the schedule of the project can be seen on the left side of the staffing table. Within the table, the expected working hours for each task are listed alongside the position(s) that will oversee completing these tasks. A total of 710 personnel hours will be needed to complete the project. The detailed staffing table may be found in Appendix B. A summary of the staffing table including the major tasks can be seen in Table 4 - 2. The summary table also includes the individual staffing hours, the sum of all hours for each position, and the sum of all hours per major task.

Task	SENG Hours	ENG Hours	TECH Hours	DRFT Hours	Total Hours
1.0 Project Background Research	0	20	0	0	**20**
2.0 Preliminary Analysis and Design	5	45	0	0	**50**
3.0 Final Analysis and Design	20	100	30	30	**180**
4.0 Bridge Production	20	20	60	80	**180**
5.0 Assembly	5	20	50	20	**95**
6.0 Competition Preparation	5	0	15	0	**20**
7.0 Project Deliverables	20	55	20	0	**95**
8.0 Project Management	35	20	10	10	**75**
Subtotal	**110**	**275**	**185**	**140**	**710**

Table 4 - 2 : Summary of Staffing Hours

5.0 Cost of Engineering Services

5.1 Summary of Cost

Cost of Engineering Services	
Cost Section	**Subtotal**
1.0 Personnel	$92,635
2.0 Travel	$3,280
3.0 Subcontract	$9,219
4.0 Miscellaneous	$4,618
Total Cost	$109,752

Table 5 - 1: Cost of Engineering Service Summary Table

5.2 Budget Justification

5.2.1 Personnel

The personnel category lists the hours of each position worked, the hourly rate of each position, the cost of each personnel's services, and the total working hours cost of the project. The hourly rate also includes the overhead of the project and benefits for each team member. All factors listed have been implemented in the hourly rate by a multiplier for each position. The total cost of the personnel hours can be found in Appendix C

5.2.2 Travel

The travel category includes all anticipated expenses to acquire the materials from fabrication as well as the cost of travel to attend the ISWS. The truck rental is to transport the equipment and the mileage was estimated based on the distance from the storage unit and the fabrication site. The rental van had been chosen to transport the team to ISWS in one vehicle to reduce costs. The mileage was estimated based on the travel distance from Northern Arizona University to Utah State University. The travel expense also includes the hotel stay and per diem. To reduce hotel expenditures, the team will be divided into two groups where each group has been assigned a hotel room each night for the duration of the competition. A per diem was added to the expense list to account for the food expenses anticipated for each team member. All expenses for travel have been tabulated in Appendix C.

5.2.3 Subcontract

The subcontract category includes the estimated cost of fabricating the project. This subcontract will include the welder’s pay rate and anticipated hours required to finish fabricating the project. Alongside this, an additional 5% had been added to the charge which includes the time and labor to develop the contracts for this work. Clarification can be found in Appendix C.

5.2.4 Miscellaneous

The miscellaneous category includes the anticipated supplies and rental equipment necessary to complete the project. The supplies required to complete the project include purchasing fasteners, steel, tool belts for the team, and the lab rental required to do the design analysis. The fasteners will be purchased based on the number of connections the team anticipates having throughout the build including potential defective fasteners. The steel cost is estimated based on the amount of steel the team anticipates using for the bridge itself. Four tool belts are to be purchased for the use at competition. Based on the schedule found in Appendix A, the team estimates to need 24 days of lab time to properly model and analyze the structure. The equipment required to complete the project will include battery-powered drill wrenches. The power drills will be supplied by the team, and the rental cost of the equipment is included to account for the wear and tear the equipment will endure for preliminary assemblies and competition. Wrenches will be purchased for connections that cannot easily be bolted in with the drill during competition, and a rental cost has been implemented. Unit costs for all items can be found in Appendix C.

6.0 References

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Appendices

Appendix A: Project Schedule

Task Name	Duration	Start	Finish
Kickoff Meeting	0 days	Mon 9/4/23	Mon 9/4/23
Task 1: Project Background Research	17 days	Mon 9/4/23	Tue 9/26/23
Task 2: Preliminary Analysis and Design	**22 days**	**Wed 9/27/23**	**Thu 10/26/23**
Task 2.1: Member Design and Analysis	7 days	Wed 9/27/23	Thu 10/5/23
Task 2.2: Material Specifications	2 days	Fri 10/6/23	Mon 10/9/23
Task 2.3: Connection Design	10 days	Fri 10/6/23	Thu 10/19/23
Task 2.4: Design Matrix	1 day	Thu 10/26/23	Thu 10/26/23
Task 3: Final Analysis and Design	**20 days**	**Fri 10/27/23**	**Thu 11/23/23**
Task 3.1: Design Modeling	15 days	Fri 10/27/23	Thu 11/16/23
Task 3.2: Strength Analysis and Design	16 days	Thu 11/2/23	Thu 11/23/23
Task 3.3 Serviceability Analysis and Design	16 days	Thu 11/2/23	Thu 11/23/23
Task 3.4: Connection Analysis and Design	16 days	Thu 11/2/23	Thu 11/23/23
Task 4: Bridge Production	**38 days**	**Tue 11/28/23**	**Thu 1/18/24**
Task 4.1 Shop Drawings	15 days	Tue 11/28/23	Mon 12/18/23
Task 4.2: Fabrication Coordination	38 days	Tue 11/28/23	Thu 1/18/24
Task 4.3 Mentee Collaboration	101 days	Tue 11/28/23	Tue 4/16/24
Task 5: Assembly	**59 days**	**Fri 1/19/24**	**Wed 4/10/24**
Task 5.1: Conduct Initial Assembly of Members	10 days	Fri 1/19/24	Thu 2/1/24
Task 5.2: Design Modifications	20 days	Fri 2/2/24	Thu 2/29/24
Task 5.3: Practice Assembly Prior to Competition	29 days	Fri 3/1/24	Wed 4/10/24
Task 6: Competition	3 days	Thu 4/11/24	Mon 4/15/24
Task 7: Project Deliverables	**71 days**	**Fri 1/19/24**	**Fri 4/26/24**
Task 7.1: 30% Deliverable	23 days	Fri 1/19/24	Tue 2/20/24
Task 7.2: 60% Deliverable	20 days	Wed 2/21/24	Tue 3/19/24
Task 7.3: 90% Deliverable	25 days	Wed 3/20/24	Tue 4/23/24
Task 7.4: Final Report	3 days	Wed 4/24/24	Fri 4/26/24
Task 7.5: Project Website	71 days	Fri 1/19/24	Fri 4/26/24
Task 7.6: Final Presentation	71 days	Fri 1/19/24	Fri 4/26/24
Task 8: Project Management	**168 days**	**Mon 9/4/23**	**Wed 4/24/24**
Task 8.1: Schedule Management	168 days	Mon 9/4/23	Wed 4/24/24
Task 8.2: Resource Management	168 days	Mon 9/4/23	Wed 4/24/24
Task 8.3: Meetings	168 days	Mon 9/4/23	Wed 4/24/24

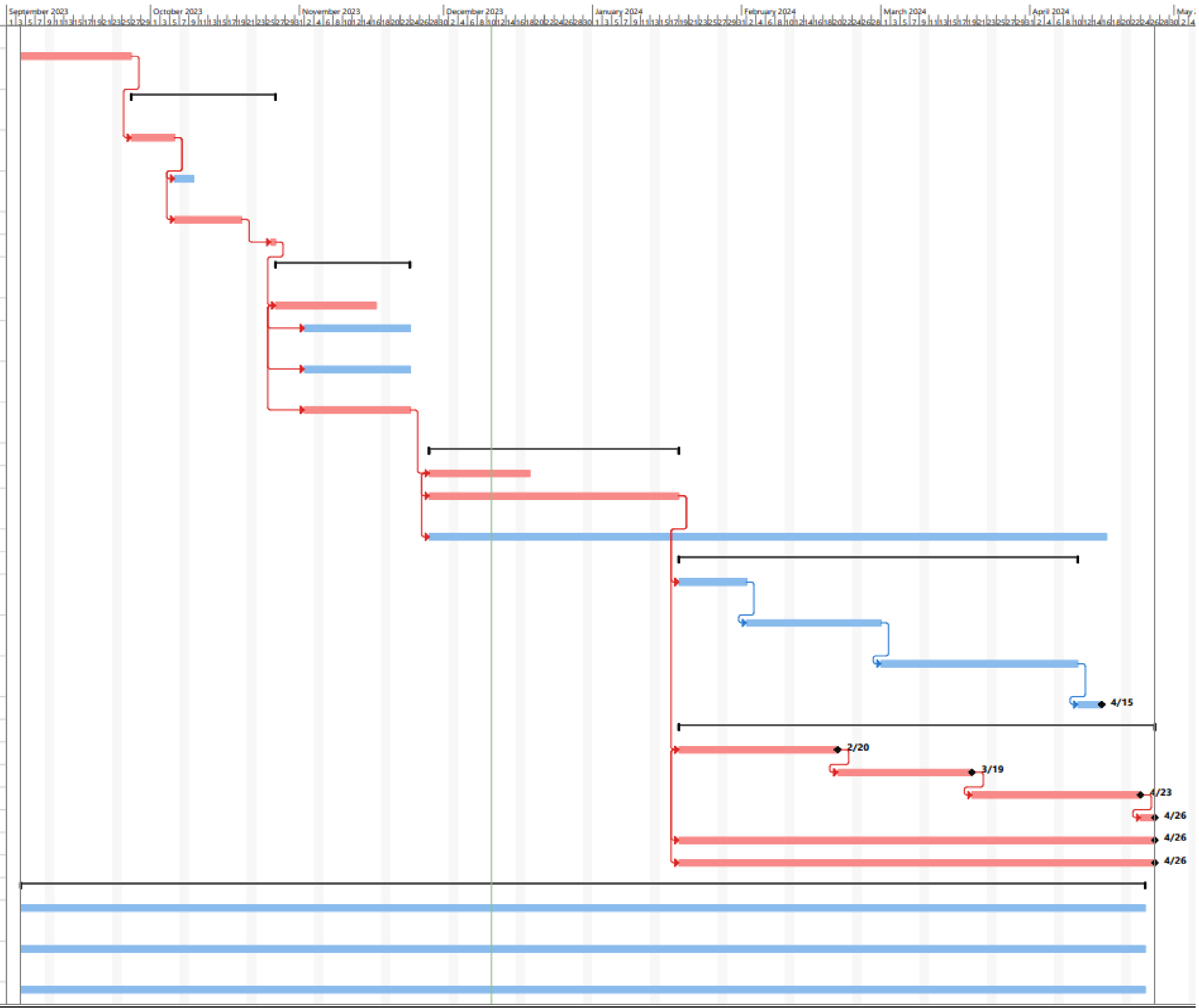

Figure A - 1 : Project Schedule

Appendix B: Staffing Table

Table B - 1: Staffing Table

Task	SENG Hours	ENG Hours	TECH Hours	DRFT Hours	Task Hours
1.0 Project Background Research		20			20
2.0 Preliminary Analysis and Design					0
2.1 Member Design and Analysis		20			20
2.2 Material Specifications		5			5
2.3 Connection Design		20			20
2.4 Design Matrix	5				5
3.0 Final Analysis and Design					0
3.1 Design Modeling	5	20		30	55
3.2 Strength Analysis and Design	5	30	10		45
3.3 Serviceability Analysis and Design	5	20	10		35
3.3 Connection Analysis and Design	5	30	10		45
4.0 Bridge Production					0
4.1 Shop Drawings		10	20	80	110
4.2 Fabrication Coordination		10	40		50
4.3 Mentee Collaboration	20				20
5.0 Assembly					0
5.1 Conduct Initial Assembly of Members			20		20
5.2 Design Modifications		10	10	20	40
5.3 Practice Assembly Prior to Competition	5	10	20		35
6.0 Competition Preparation	5		10		15
7.0 Project Deliverables					0
7.1 30% Deliverable	2.5				20
7.2 60% Deliverable	5				20
7.3 90% Deliverable	5				10
7.4 Final Report	5				5
7.5 Project Website			20		20
7.6 Final Presentation	2.5	10			20
8.0 Project Management					0
8.1 Schedule Management	10				10
8.2 Resource Management	10				10
8.3 Meetings	15	15	10	10	55
Subtotal	110	275	185	140	710

Appendix C: Cost of Engineering Services Table

Table C - 1 : Cost of Engineering Services

Cost Estimate of Engineering Services				
1.0 Personnel	**Classification**	**Hours**	**Rate, $/hr**	**Cost**
	SENG	110	$216	$23,760
	ENG	275	$131	$36,025
	TECH	185	$114	$21,090
	DRFT	140	$84	$11,760
			Subtotal	**$92,635**
2.0 Travel	**No.**	**Unit**	**Unit Cost**	**Cost**
Rental Truck	5	Days	$129	$645
Truck Fuel	1232	Miles	$0.22	$271
Rental Van	3	Days	$48	$145
Van Fuel	1100	Miles	$0.45	$242
Hotel	9	Rooms(3-nights)	$113	$1,017
Per Diem	6	People ($40/day)	$40	$960
			Subtotal	**$3,280**
3.0 Subcontract		**Hours**	**Rate, $/hr**	**Cost**
Fabrication		$100	$92	$9,219
4.0 Misc.	**No.**	**Unit**	**Unit Cost**	**Cost**
Supplies				
Steel	147	LFT	$8.61	$1,266
Tool Belt	6	Belts	$30	$180
Bolts	100	Bolts	$0.44	$44
Nuts	100	Nuts	$0.44	$44
			Subtotal	**$1,534**
Equipment				
Wrenches (Usage)	12	Person Days	$7	$84
Battery-Powered Drill (Usage)	12	Person Days	$50	$600
Lab Rental	24	Days	$100	$2,400
			Subtotal	**$3,084**
5.0 Total Cost				**$109,752**