Northern Arizona University
Student Steel Bridge Competition 2023

Student Steel Bridge 2022-2023
Final Proposal

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1.0 Project Understanding

1.1 Project Purpose

The purpose of this project is to design a 1:10 scale model of a bridge to take to the regional Student Steel Bridge Competition 2023 (SSBC 2023). The regional competition that the NAU team will be attending will take place in the month of April and will be hosted by the University of Nevada Reno. Selected Teams from the regional events will compete nationally to be awarded the design/build contract. To be able to advance to Nationals, regional teams shall rank high in most of the competition categories.

This project will also serve as the Civil Engineering Senior Capstone for the school year 2022-2023. The Capstone Team will complete the design and construction of the proposed bridge and take it to competition. This will include completing course requirements, obtaining a budget, selecting materials, creating shop drawings, practicing assemblage, and performing in the SSBC.

1.2 Project Background

1.2.1 Design Background

The competition's hypothetical client is the San Diego National Wildlife Refuge, SDNWR, who are requesting the design of a bridge with piers at specified locations. This new design intends to replace the existing bridge at the site shown later. This bridge will cross the Sweetwater River to allow for better access to park service vehicles, pedestrians, bicyclists, horses, and emergency vehicles. The client specifies the use of steel for many reasons, some being strength, construction speed, and tribute to the Sweetwater River Bridge. Below is an image, Fig. 1, that represents the project vicinity that illustrates the path of the river and the location of the SDNWR. Figure 1 also pinpoints the location of the existing Sweetwater River Bridge.

Figure 1. Project Site Map

The Sweetwater River Bridge was constructed in 1929 and became a pedestrian-only bridge in 1987. To allow the San Diego Wildlife Refuge, which was established in 1996, access to both sides of the river, the client is proposing the bridge to be located further down the Sweetwater River Bridge. For competition purposes, the bridge model will not include the deck, foundations, and approaches [1].Figure 2 is a street view of the existing bridge structure, depicting the current truss configuration.

Figure 2. Street View

1.2.2 Competition Background

The bridge will be assembled by 6 team members: 4 capstone students and 2 mentees from the American Society of Civil Engineers (ASCE). For regionals, if the bridge is assembled in less than 30 minutes, and isn't violating any safety regulations, it is eligible to be considered for a multitude of performance-related awards.

During construction, the team will be penalized for accidents such as safety violations, touching the inside of the river boundary, dropping any materials in the river, and/or advancing on the bridge construction by committing an accident. The competing team is also not allowed to leave the construction site with any construction parts or make any adjustments to their bridge after the team captain has informed the judge to stop the clock.

The following will be used to judge the bridge:

- Aesthetic: To win this award, the team will be judged on Bridge appearance and on the poster that describes the design of the bridge. If a poster isn't presented, the bridge will receive a low score in the Aesthetic category [1].

- Construction Speed: The team with the lowest total time will be awarded Construction Speed. This time will include any time penalties given to the Team during Construction [1].

- Lightness: The team with the lowest total weight will be awarded the Lightness category. This weight will include any load penalties given to the Team during Construction [1].

- Stiffness: The team with the lowest total deflection (sum of both measured points rounded to the nearest 0.01 inch) will be awarded the stiffness category. Deflection is determined from measurements outlined in the SSBC rules [1].

- Construction Economy: The team with the lowest construction cost will be awarded the construction economy. The construction cost, *Cc*, will be determined by taking the total length of construction time multiplied by the amount of the builder's present [1].

- Structural Efficiency: The team with the lowest structural cost will be awarded structural efficiency. The construction cost, *Cs*, will be determined by taking the total bridge weight multiplied by a set material cost [1].

- Overall Performance: The team with the lowest sum of construction cost, structural cost and any fines incurred as a result of violations wins the overall competition.

- Cost Estimation: An award will also be rewarded to the team that best estimates overall performance and completes the competition.

1.3 Technical Considerations

The team will design a bridge according to the constraints and criteria outlined within the SSBC 2023 Rules. Due to the variability in loading, bridge members will be designed to handle any of the possible load cases. The following table provides the loading locations for the vertical and lateral load tests.

Table 1. Competition Load Placements

N	L1	L2	S
1	4'-0"	7'-6"	7'-0"
2	4'-6"	8'-6"	7'-0"
3	7'-0"	13'-0"	10'-0"
4	8'-6"	13'-6"	13'-0"
5	10'-0"	15'-0"	10'-0"
6	11'-6"	16'-0"	13'-0"

Truss patterns, member length, as well as member cross-sections will be selected to minimize vertical deflection and horizontal sway, while maximizing the portability of the structure when packed. With overall weight of the bridge being a significant factor during judging, the bridge must accomplish the preceding all while using as little material as possible. A majority of the design will be completed with the structural modeling software RISA. Hand calculations will be employed on critical members or structurally complex sections of the bridge. An important consideration is the ease of assembly of any finished project. A significant portion of the competition is bridge assembly; thus, the design must be efficient and quick to put together. The following figures show the bridge envelope for design and the construction site plan.

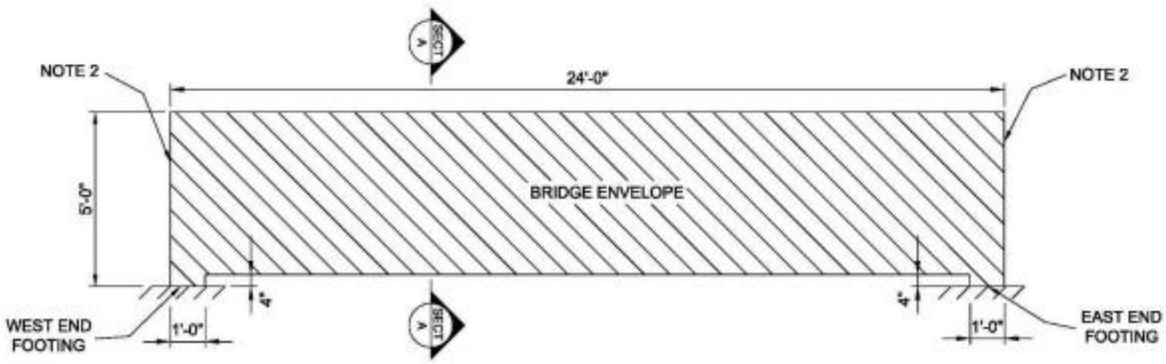

Figure 3 - Bridge Envelope

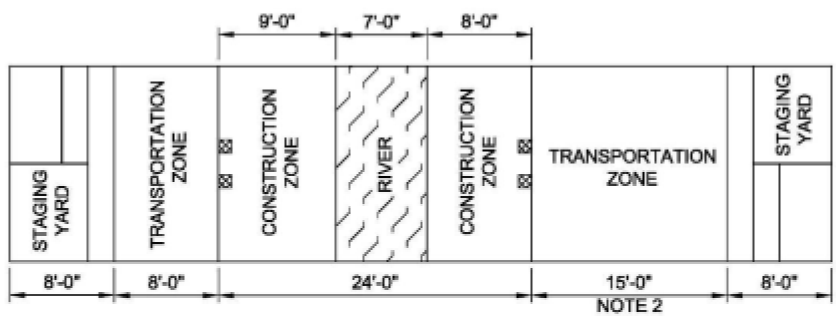

Figure 4 - Construction zone

Connections will be created which meet or exceed the expected strength requirements at that joint, while also remaining as simple as possible to assemble under timed competitive conditions. Because of their importance and relative complexity, analysis of these connections will take place both through the mechanical modeling software SolidWorks, and through the use of hand calculations.

Materials will be carefully selected from the available pool of resources the team has at its disposal. Given the competitive atmosphere of this project, a high strength to weight ratio is a priority.

At the conclusion of the design phase of the project, a full set of technical details and shop drawings will be prepared. These documents will be used by specialists outside the design team as reference materials during fabrication. These documents are expected to communicate all relevant design specifications, such as material type, weld electrode, dimensions, and any tolerances if applicable. Upon delivery of the finished components, the team will inspect each part for compliance, and attempt an initial assembly if safe. If any major deviations (or a combination of minor deviations) are discovered which has the potential to significantly affect the expected performance of the bridge, the team will resolve the issue(s) by performing modifications to the bridge, attempting repair work, or working with the manufacturer.

1.4 Potential Challenges

The 2023 SSBC allows students to expand their knowledge beyond the classroom through participation in the engineering design process: given the constraints found in the rulebook, teams will take a project from the conceptual phase on through fabrication, and then final delivery to the client. Given the complexity of this project, the team is expected to face challenges in several areas and must develop a solution to each of these in order to produce a successful design.

Initially, it is expected that the team will be operating with knowledge gaps. These are areas of technical competency needed for the success of the project that are either not adequately developed at this stage of their professional careers or are not normally included in civil engineering curriculum. To solve this issue, members will identify critical tasks related to the several project phases, determine what skills/proficiencies they require, and research these topics to a sufficient depth. A good example of this during the design phase could be exposure to new structural modeling software, some having steep learning curves. Working through published tutorials will help build the foundation for drafting in these programs. Another possible technical challenge may be found in the fabrication stage, where cutting, milling, or welding of steel will take place. These areas will require not only research into specialized disciplines, but also practical experience in applying these techniques with any degree of reliability. Consultation with professionals in these fields may provide the team with the necessary skills to complete these tasks.

Besides technical considerations, there are also challenges pertaining to the competition itself that may severely affect the outcome of the project. The competition provides an array of guidelines for each section and subsection of the competition; these relate allowable materials, construction methods, or safety requirements. Failure to comply with or follow these rules will result in penalties, disqualification in categories, and/or loss of participation in the competition. A firm understanding of the rules and guidelines, attention to detail during the design phase, and frequent reference back to the rulebook when making design decisions will eliminate these risks, and help the team bring a successful bridge to the competition.

1.5 Stakeholders

This competition has several potential stakeholders, and they are as follows:

- San Diego National Wildlife Refuge - The proposed design affects both appearance and access for the Refuge’s trail system. If executed poorly, this could reflect negatively.

- NAU’s Engineering Department and ASCE Student Chapter - The team performance directly reflects upon the school engineering department and the student chapter. A poor display at competition could have negative effects on reputation and further opportunities.
- AISC and Competition Sponsors - These groups provide schools with funding and material thus a satisfactory performance is expected. The inability to perform adequately could be seen as a loss of money and material.

2.0 Scope of Services

2.1 Task 1.0: Background Research

2.1.1 Task 1.1 Competition Rules

It is essential for the entire team to read and understand the entire SSBC 2023 Rules. The rules will be discussed between all competing team members, which include the 2 ASCE mentees, to ensure the best interpretation and that all team members are complying with rules and expectations during competition.

2.1.2 Task 1.2 Analysis Methods

A list with all of the available analysis methods needs to be created to determine the best software or techniques to account for the design loads. RISA is the preferred method for creating and analyzing the final bridge design. An adequate understanding of this software will be required to perform analysis of load cases to determine potential cases of failure. The RISA software does not have the capabilities of modeling connections; therefore, shear values will be gathered from the software and connections will be made and analyzed using SolidWorks or AutoCAD.

2.1.3 Task 1.3 Types of Trusses Patterns and Connections

Several different types of truss designs need to be considered in the drafting process in order to increase chances of a successful bridge design. Along with the truss designs, example connections must be researched in order to acquire an understanding of how the members will connect and possible ways these connections may fail.

2.1.4 Task 1.4 Material Properties and Material Selection

It is stated in the SSBC 2023 Rules that the bridge has to be made out of magnetic metal. The team will use a metal that will be magnetic, light, and cost efficient. Chosen material should also be strong enough to withstand heavy loads, and preferably lightweight. The material will be selected based on cost and availability.

2.2 Task 2.0: Designing

2.2.1 Task 2.1 Preliminary Sketches

The team will create several potential bridge designs prior to modeling. These designs will be used to consider different truss patterns and bridge orientations. This will also be done to determine potential stringer configurations and potential member sizing and configurations. The team will meet with our client to discuss the advantages and disadvantages of the potential bridge designs.

2.2.2 Task 2.2 Member Selection

Member selection will be determined by the SSBC rules and guidelines. This entails determining the overall width, height, and length of the bridge. Moreover, background research for the dimensions of the height of the stringers and how far off the surface can the bridge start construction.

2.2.3 Task 2.3 RISA Modeling and Analysis

Using RISA 3D, several bridges that meet the design criteria and fit within the construction envelope will be prepared. These designs will be used to evaluate the best configuration to handle the several load configurations discussed above. The team is aware that the RISA software won't suffice to complete the design and will be potentially supplementing RISA results with hand calculations and other software analyses.

2.2.4 Task 2.4 Connection Modeling and Analysis

Connections will be designed to handle the extreme shear and bending moment forces exerted on the bridge. This will include modeling of "simple" connections such as bolts in order to ensure they do not fail, as well as creating more complicated connections to speed up assembly time during competition.

2.2.5 Task 2.5 Select Final Design

A decision matrix will be made to evaluate each of the bridge designs. This decision matrix will include all of the following criteria: structural efficiency, weight, constructability, aesthetics, and overall structural stability. A number of designs will be scored within the matrix and the highest score will be selected to move forward.

2.2.6 Task 2.6 Material Procurement

Once the final design has been selected, the team will coordinate with a local manufacturer, Page steel, to acquire steel for fabrication and construction. Further material needs will be fulfilled through shop drawings later.

2.3 Task 3.0: Fabrication

2.3.1 Task 3.1 Fabrication Documents

The SSBC team will prepare a series of drawings and technical notes for use by outside contractors. Critical dimensions, tolerances, welds, and material specifications will be called out.

2.3.2 Task 3.2 Fabrication Oversight

The SSBC team will participate in several critical manufacturing steps by providing shop drawings, technical specifications, and will determine if any portion of the construction needs to be considered. The connections will likely require frequent communication with the manufacturer due to the stresses associated with them. Redesign may be required for components if structural or safety concerns show up during this step as well. All changes to the technical specifications of the shop drawing will be discussed and determined by the SSBC team.

2.4 Task 4.0: Testing Prior to Competition

2.4.1 Task 4.1 Pre-load Bridge

Since applying the full competition load of 2500 lbs can strain members and connections, the team will put the bridge through a series of tests to predict performance at competition. These tests will determine if the design in its current state complies with the 2023 SSBC rules and guidelines. The first will consist of a visual safety inspection of all individual components, as well as the assembled bridge itself. Once deemed safe, the team will determine how closely the finished design compares to the analytical model used to develop shop drawings. 100 lbs of preload will be applied at the L1 and L2 positions, with any effects or failures carefully documented. If nothing of concern occurs, the team will move on to the lateral and vertical load tests.

2.4.2 Task 4.2 Lateral load test

The lateral load test consists of a 50 lb weight applied at point S in the horizontal direction, as shown in Table 1. The deflection of the bridge in response to this weight will be recorded and compared to the associated load case in the analytical model created in RISA. If the deviation between the two is excessive, or if the deflection exceeds 1", the team will modify the bridge to bring it within compliance.

2.4.3 Task 4.3 Vertical load test

The Vertical load test will assess the bridge's ability to carry the full competition load of 2500 lbs without exceeding the maximum deflection. Similar to competition guidelines, Cinder Blocks will be placed beneath the bridge to prevent a catastrophic failure from injuring anyone nearby. Known weights will then be applied at each location specified in the rulebook, and any deflections measured. Like the lateral load test, these loads will be replicated in the analytical model, and the resulting deflections compared. If the two deviate significantly, or the design exceeds the allowable deflection of 2", the team will return to the design phase, and develop strategies to bring the bridge into compliance.

2.5 Task 5.0: Practice

2.5.1 Task 5.1 Practice Constructing Bridge

The first step of the competition is to understand how to build the bridge as a team. A series of practice runs will be done to familiarize the team on how to build the bridge efficiently in accordance with the SSBC 2023 Rules.

2.5.2 Task 5.2 Practice Construction Speed of the Bridge

Once the team is familiar with building the bridge from different avenues and with a clear understanding of each construction path, building towards speed will be our next step to be competitive in the building speed portion of the competition. It is pertinent that every builder knows the rules on the construction speed to minimize penalties. The goal of this task is to shave time off construction time in order to receive a competitive score in the construction cost category.

2.5.3 Task 5.3 Competition Management

Competition management will test every team member's understanding of the competition. Each member must fully understand both the rules and their role during the build portion of the competition to ensure a quick and successful build. When the assemblage is considered satisfactory, the team will color code members to facilitate construction. Once color coded, each member of the team will be assigned a portion of the construction to facilitate competition management.

2.6 Task 6.0: Competition

2.6.1 Task 6.1 Travel Arrangements

As a representative of NAU for the 2023 SSBC, the team is expected to coordinate efforts with the local ASCE chapter on campus. Lodging, transportation, and all associated costs must be communicated to the ASCE Treasurer, who will arrange reservations for the team at the 2023 ISWS conference held in Reno, NV.

2.6.2 Task 6.2 Competition Day

Prior to and on the day of competition, the team will review rules and regulations pertaining to scoring and competition, in order to avoid violations that can detrimentally affect the team's final scoring. In addition, the team will clarify roles, responsibilities, and lessons learned during practice, to ensure the team operates effectively and efficiently.

2.7 Task 7.0: Project Impacts

The team will evaluate several areas that the bridge project could affect. First, the social impacts which could affect the reputation of NAU and project sponsors. Additionally, the team will evaluate how the project can affect the professional development of the team's members. Finally, the team will examine some of the economic and environmental impacts of the bridge project.

2.8 Task 8.0: Project Deliverables

2.8.1 Task 8.1 Thirty Percent

The 30% Effort will consist of Tasks 1 and first subtask of Task 2, which includes the background research and preliminary sketches with matrices. The sketches will be made with respect to the competition ruling for loading and dimensions outlined in the SSBC rules. Decisions matrices will be made to further decide on potential designs. This will be completed by the end of October. The 30% Deliverable for Capstone will reflect the 30% progress for the Report, Presentation, Website, and Schedule. This should be completed during the 5th week of the Spring Semester and should only reflect the progress the Team made up to the 30% Effort.

2.8.2 Task 8.2 Sixty Percent

The 60% Effort will consist of the remainder of Tasks 2 and Tasks 3 and 4. This includes the final design, fabrication, and loading. The final design will include material selection, RISA modeling, and connection design. The fabrication period consists of creating the shop drawings and fabrication overview. Once the bridge has been constructed, it will be lightly loaded to ensure that there aren't any obvious deflections. This will be completed by the third week of March. The 60% Deliverable for Capstone will reflect the 60% progress for the Report, Presentation, Website, and Schedule. This should be completed during the 9th week of the Spring Semester and should only reflect the progress the Team made up to the 60% Effort.

2.8.3 Task 8.3 Ninety Percent

The 90% Effort will consist of Tasks 5, 6 and 7. These Tasks cover practice, competition, and exploring project impacts. Construction practice is essential to decrease construction time during competition and ensure that all members are color coded correctly, the color coding should be visible to every member. It is also during practice where construction tasks will be assigned to each team member. Competition has a duration of 3 days; the Team needs to ensure that all travel arrangements have been made and that the Competition schedule is known by all members. This will be completed towards the end of April. The 90% Deliverable for Capstone will reflect the 90% progress for the Report, Presentation, Website, and Schedule. This should be completed during the 13th week of the Spring Semester and should only reflect the progress the Team made up to the 90% Effort.

2.8.4 Task 8.4 Final Deliverables

The Final Effort, at this point, consists of the Final Deliverables. This will be a reflection of competition results and final Report, Website, and Schedule. This should be completed during the last week of the Spring Semester. The final Report and Presentation will be prepared with the objective and scope of the project, as well as the outcome of competition and overall analysis that will be presented at the Undergraduate Symposium. The completed website will display a plan set, as well as all associated information and documentation regarding the project and competition.

2.9 Project Management

2.9.1 Schedule

Coordinate between team members to ensure that all work is accounted for and completed in a set amount of time. A google calendar is set up to ensure that each member of each individual team member’s schedule is accounted for. Microsoft Project will be used to provide an in-depth chart of project completion time and be used to maintain organization.

2.9.2 Meetings

There are 4 different types of meetings occurring for the team. The first type of meetings are team meetings. These meetings occur up to 4 times a week and are used to advance in the bridge design and in Capstone assignments.. The other three types of meetings are necessary for the team's success and therefore a requirement for Capstone. These are meetings with the Client, Technical Advisor, and Grading Instructor and should happen at least 4 times during the Fall semester. Meetings with the Client will consist of progress updates and competition inquiries. Meetings with the Technical Advisor will be about any potential questions regarding software and other design and competition related issues. Meetings with the Grading Instructor will happen to ensure that Capstone deliveries meet desired standards. A Google Drive has been created to organize and track all of the meeting minutes and important documents.

2.9.3 Communication

The Capstone Team has different methods of communication established. These methods include: a Google Drive for document sharing consisting of all pertinent information, a Discord chat for communication outside of Capstone meetings, and emails for professional communication that needs to be documented.

2.9.4 Resource Management

The team is provided with multiple resources throughout the design and development of the steel bridge. Some of these resources include a technical advisor, access to NAU's faculty members, ability to reach out to AISC staff, AISC grant, and no-cost fabrication. The team is responsible for knowing how to manage these resources to be able to take full advantage of them. Utilizing all of the resources available should allow the team to be successful in the competition.

2.10 Exclusions

The SSBC 2023 is limited to design and fabrication of structural members, connections and joints. This excludes any aspects related to decking, pavement and footings. This exclusion extends to full-scale construction of any potential design. The team is also not responsible for traffic impact analysis related to the SD NWR trail system or the exact location/placement of the new bridge.

3.0 Scheduling

Table 1 shows a summarized schedule for the SSBC capstone. The full GANNT chart can be found in Appendix A.

Table 2. Scheduling

Task Name	Duration	Start	Finish
Task 1.0 Background Research	30 days	Thu 9/8/22	Wed 10/19/22
Task 2.0 Designing	54 days	Thu 10/20/22	Tue 1/10/23
Task 3.0 Fabrication	55 days	Wed 12/14/22	Tue 3/7/23
Task 4.0 Testing Prior to Competition	10 days	Wed 3/8/23	Tue 3/28/23
Task 5.0 Practice	10 days	Wed 3/29/23	Tue 4/11/23
Task 6.0 Competition	2 days	Thu 4/13/23	Fri 4/14/23
Task 8.0 Deliverables	51 days	Thu 2/16/23	Thu 5/4/23
Task 9.0 Project Management	162 days	Thu 9/8/22	Fri 5/5/23

4.0 Staffing

4.1 Required Personnel

To successfully complete this project, there are a total of 4 positions needed to be filled by each of the team Capstone team members at any given time. These positions won't be assigned to any team member for the duration of the project, rather, each team member will be assigned different positions throughout the completion of the project. The positions are listed below on **Table 2**.

Table 3. Required Personnel

Classification	Code
Senior Engineer	SE
Project Engineer	PE
Engineer in Training	EIT
Drafter	DRF
Engineering Intern	INT

4.1.1 Personnel Qualifications

To ensure that the project is completed successfully, it is crucial that the team working on the project has all of the required qualifications. From Table 2, each of the personnel's' qualification descriptions are presented below:

Senior Engineer

The Senior Engineer oversees the progress and quality of the project. For this specific project, the Senior Engineer will oversee RISA modeling and analysis, the creation of the final design with the fabrication documents, and fabrication and loading of the model bridge. The Senior Engineer will also handle the front-end conversations for material acquisition, traveling arrangements, and competition management. He or she must represent the team in these conversations, ensuring that everything remains professional, ethical, and courteous.

Project Engineer

The Project Engineer's (PE) duties resemble that of the Senior Engineer. The PE will spend most of their budgeted time with the design, fabrication, and testing. Being more hands-on than the Senior Engineer, they will collaborate with the drafter to ensure that the design meets all of the rules and regulations as well as the strength required. The PE will also spend time developing the deliverables to ensure they are submitted on time and contain and relate the required information.

Engineer in Training

The Engineer in Training (EIT) will be working closely with the PE to gather experience. The EIT will be performing a large amount of design and analysis work under supervision and guidance of the PE. They will also take part in drafting shop drawings, deliverables and reports.

Drafter

For this project, the Drafter is responsible for knowing the competition rules and regulations to ensure that the design will be successful. The Drafter will load the design into RISA and will spend time drafting the fabrication documents. The Drafter can use units specified by the providers to facilitate fabrication. They are also capable of including all the required information for the providers to ensure that the bridge construction runs smoothly.

Engineering Intern

In addition to technical roles necessary for the success of this project, several interns will be retained. It is expected that interns will assist other roles in various tasks by shadowing them throughout the course of the project. While their help will be required for certain aspects of the project, the primary goal is for interns to gain experience in the design and fabrication process, so that they may be successful in their future careers.

4.2 Staffing Schedule

Appendix B shows the expected hours for each of the outlined roles in Table 2 per task outlined in Table 1. This includes a cumulative number of hours for each task as well as the entire project. A total of 670 hours is projected for the completion of the project.

4.2.1 Hour Distribution

The total line in Appendix B, the last line of the table, shows how many hours correspond to each staff member. The Drafter has been given 85 hours total for the duration of the project. These hours will be spent on creating the design and fabrication documents. Once that is completed, the Drafter will not play a role in the remainder of the project. It is the EIT (165 hours) and the Intern (166 hours) that will be given the most hours, due to the fact that they will be slower in completing a task since they are still learning the process. They will both be heavily involved in documentation, design, fabrication, and deliverables throughout the entire project. On the other hand, the Senior Engineer and the PE will be given a smaller number of hours since they are the most experienced and can get tasks done efficiently.

5.0 Cost of Engineering Services

Table 3 includes the cost of engineering services for the Steel Bridge project. Costs are calculated based on University Transit Services and the State of Arizona Accounting Manual Section 5095. This table also includes rate breakdown for each of the positions outlined in Table 2. The project is to have an estimated cost of approximately $72,857.

Table 4. Cost of Engineering Services

Cost of Engineering Services				
Classification	**Details**	**Rate**	**Quantity**	**Cost, $**
1.0 Personnel	**Title**	**$ per hr.**	**Hours**	**Total**
	Senior Engineer	$180.00	124	22,320
	Project Engineer	$140.00	130	18,200
	Engineer in Training	$70.00	165	11,550
	Drafter	$75.00	85	6,375
	Intern	$35.00	166	5,810
	Total Personnel			64,255
2.0 Supplies	Members	$3/lb	250 lb	750
	Bolts	$0.01/unit	200	2
	Plates	$3/lb	10 lb	30
	Supplies Cost			782
3.0 Subcontract	Labor	$65.00	60	3,900
4.0 Travel Expenses	Lodging	$170/person/night	4 nights	2,720
	Rental	$68/day	5 days	340
	Mileage	$0.45/per mile	691x 2 miles	622
	Travel Cost			3,682
Total Project Cost				72,619

Aside from Personnel cost, Table 3 shows the cost for the material, labor, and the competition travel expenses. Since the project consists of only the 1:10 model, the cost seems very low because all of the members will be rather small. After the Senior Engineer spoke to the subcontractors that will be providing the material, the team was able to obtain a cost per unit for the material that will be required. This includes the metal members, the metal plates, and the connections that have been factored into the metal plates and the labor cost. It has been determined that the metal will cost approximately $1,020.

The team will also hire a professional welding contractor to assist with fabrication. It has been estimated that there will be a total of 60 hours allocated to completing fabrication at a rate of $65 per hour. Note, these 60 hours of labor are separate from the hours the team personnel will be using for fabrication. This gives a total cost of $3,900 for labor.

The last expense is for the travel expenses. Since competition is in Nevada, the team has to travel from Flagstaff for a total of 1382 miles. A van will have to be rented for $68 per day for a total of 5 days with a gas rate of $0.45 cents per mile traveled. For the duration of the competition, the team will be staying at a hotel that charges $170 per night per person for 4 nights. This cost will include M&IE and lodging. The total cost for the competition travel expenses will be $3,681.90.

6.0 References

1. AISC, "Student Steel Bridge Competition - 2023 Rules," Chicago, IL 60601. [Online.] Available: Rules and Clarifications | American Institute of Steel Construction (aisc.org) [Accessed: September 25, 2022]
2. Google Earth. [Online.] Available: Sweetwater River Bridge Vicinity [Accessed: October 03, 2022]
3. AARoads California Roads. [Online.] Available: Sweetwater River Bridge Truss [Accessed: September 26, 2022]
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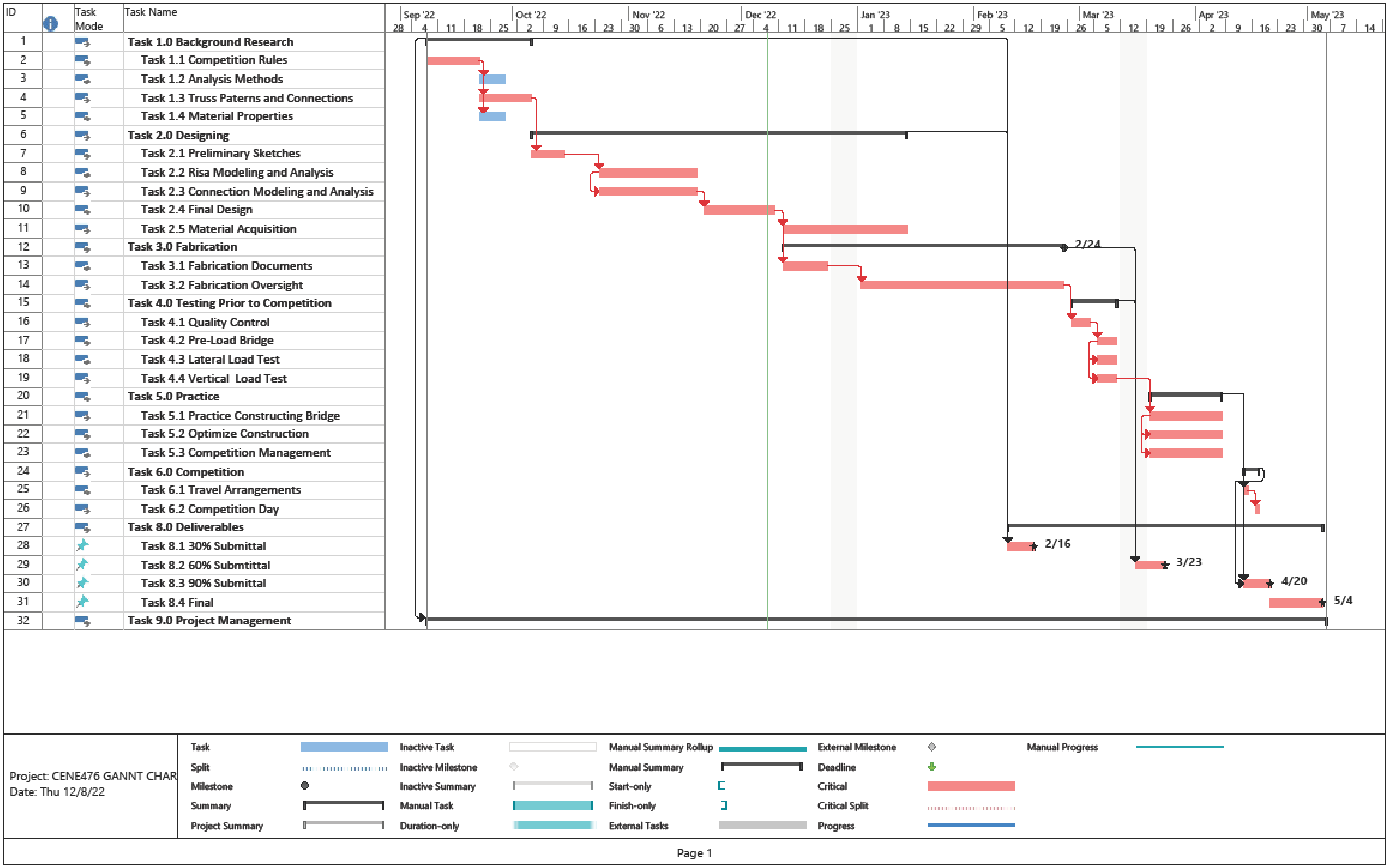
7.0 Appendices

7.1 Appendix A: GANTT Chart



7.2 Appendix B: Staffing Schedule

Task Name	Personnel					SUM
	SE	PE	EIT	DRF	INT	
Task 1.0 Background Research	7	4	16	0	16	43
Task 1.1 Competition Rules	4	4	4	0	4	16
Task 1.2 Analysis Methods	1	0	4	0	4	9
Task 1.3 Truss Patterns and Connections	1	0	4	0	4	9
Task 1.4 Material Properties	1	0	4	0	4	9
Task 2.0 Designing	23	23	45	55	42	188
Task 2.1 Preliminary Sketches	0	5	5	5	5	20
Task 2.2 Risa Modeling and Analysis	5	10	15	30	15	75
Task 2.3 Connection Modeling and Analysis	3	3	10	0	10	26
Task 2.4 Final Design	10	5	15	20	10	60
Task 2.5 Material Acquisition	5	0	0	0	2	7
Task 3.0 Fabrication	18	21	26	30	26	121
Task 3.1 Fabrication Documents	2	5	10	30	10	57
Task 3.2 Fabrication Oversight	16	16	16	0	16	64
Task 4.0 Testing Prior to Competition	10	25	25	0	25	85
Task 4.1 Quality Control	10	10	10	0	10	40
Task 4.2 Pre-Load Bridge	0	5	5	0	5	15
Task 4.3 Lateral Load Test	0	5	5	0	5	15
Task 4.4 Vertical Load Test	0	5	5	0	5	15
Task 5.0 Practice	21	17	13	0	13	64
Task 5.1 Practice Constructing Bridge	8	8	8	0	8	32
Task 5.2 Optimize Construction	5	5	5	0	5	20
Task 5.3 Competition Management	8	4	0	0	0	12

Task 6.0 Competition	13	8	8	0	12	41
Task 6.1 Travel Arrangements	5	0	0	0	4	9
Task 6.2 Competition Day	8	8	8	0	8	32
Task 8.0 Deliverables	32	32	32	0	32	128
Task 8.1 30% Submittal	8	8	8	0	8	32
Task 8.2 60% Submittal	8	8	8	0	8	32
Task 8.3 90% Submittal	8	8	8	0	8	32
Task 8.4 Final	8	8	8	0	8	32
Total	124	130	165	85	166	670