AISC STEEL BRIDGE

CENE 476C Proposal

December 12th, 2018

Kayley Adams, George Beamish, Emmanuel James, Andrew Samson
KAGE Engineering co.

Letter of Transmittal

December 12, 2018

Professor Mark Lamer
Faculty Advisor
Northern Arizona University

Dear Professor Mark Lamer,

Attached with this letter is the final proposal for the AISC Steel Bridge project. Within this document you will find the project understanding, scope of services, and project schedule. Also included are the staffing plan and the projected cost of services.

Thank you for your consideration of our company's proposal

From,

KAGE Structural Engineering Co.

Letter of Transmittal

December 12, 2018

Sabrina Ballard
EIT
Hubbard Merrell
1623 N 1st St. Flagstaff, AZ

Dear Sabrina Ballard,

Attached with this letter is the final proposal for the AISC Steel Bridge project. Within this document you will find the project understanding, scope of services, and project schedule. Also included are the staffing plan and the projected cost of services.

Thank you for your consideration of our company's proposal

From,

KAGE Structural Engineering Co.

Letter of Transmittal

December 12, 2018

Thomas Nelson
Owner
Sirius Structures
53 Michael Rd. Hamden, CT

Dear Thomas Nelson,

Attached with this letter is the final proposal for the AISC Steel Bridge project. Within this document you will find the project understanding, scope of services, and project schedule. Also included are the staffing plan and the projected cost of services.

Thank you for your consideration of our company's proposal

From,

KAGE Structural Engineering Co.

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List of Abbreviations

AISC – American Institute of Steel Construction

ASTM – American Society for Testing and Materials

ASNAU – Associated Students of Northern Arizona University

CEIAS - College of Engineering, Informatics, and Applied Sciences

HSLA – High strength, low-alloy

ksi– kips per square inch

lb – Pound Force

NAU – Northern Arizona University

SSBC – Student Steel Bridge Competition

1.0 Project Understanding

1.1 Project Purpose

The purpose of this project is to create a 1:10 scale steel bridge that models a full size bridge. The bridge will support infrastructure damaged by recent volcanic flows and earthquakes near the Hawaii Volcanoes National Park, where accessibility is a challenge. The steel bridge will accommodate only bicycles, pedestrians, park and emergency vehicles, and prohibit private motor vehicle crossings.

The bridge is to be designed, fabricated, and erected in accordance with the rules and guidelines outlined in the 2019 Student Steel Bridge Competition (SSBC) which is sponsored by the American Institute of Steel Construction (AISC). The Steel Bridge team will compete against 18 other schools at California Polytechnic State University, San Luis Obispo, on April 3rd - 6th, 2019.

The bridge submitted for competition will be judged according to aesthetics, construction speed, lightness, stiffness, construction economy, structural efficiency, and overall performance. These scoring categories will be furthered discussed in the following sections. Overall, the purpose of this project is to enter a competing bridge model that will perform exceptionally at the 2019 SSBC.

1.2 Project Background

1.2.1 Status of Design, Analysis, Planning, & Funding

The status of the project is in the design and analysis phase. The team is developing an overall geometric shape of the bridge. Once the final shape is determined, then the team will analyze the shape in RISA 3D in order to identify critical stress and moment reactions. A set schedule has not been established, but the team aim to have a final design before winter break. Once the design has been established, then the team will request for materials. Other aspects regarding construction building, display preparation, and lodging can be planned accordingly throughout the semester. The team has been contacting past companies that have donated material and services. Other funding sources will be established throughout the semester on a necessary basis.

1.2.2 Categories of Competition

1.2.2.1 Aesthetics

Section 6.2.1 of the 2019 SSBC Rules states an award is given for aesthetics if the bridge is presented exactly as it will be erected during time construction, and all parts of the assembled bridge must be visible judging. Refer to Section 6.2.1 of the SSBC 2019 Rules for further detail. [1]

1.2.2.2 Construction Speed

Section 6.2.2 of the 2019 SSBC Rules states the bridge with the lowest total time will win in the construction speed category. Total time is the time required for construction modified by construction penalties prescribed in the rules. There is also an upper limit on construction time [1].

1.2.2.3 Lightness

Section 6.2.3 of the 2019 SSBC Rules states the bridge with the least total weight will win the lightness category. Total weight is measured weight plus weight penalties prescribed in the 2019 SSBC Rules [1].

1.2.2.4 Stiffness

Section 6.2.4 of the 2019 SSBC Rules states the bridge with the lowest aggregate deflection will win the stiffness category. Aggregate deflection is determined from measurements prescribed in Section 11.5 of the 2019 SSBC Rules [1].

1.2.2.5 Construction Economy

Section 6.2.5 of the 2019 SSBC Rules states the bridge with lowest construction cost will win the construction economy category. Construction cost is computed with an equation established in this section. The equation factors in total minutes, number of builders, and load test penalties [1].

1.2.2.6 Structural Efficiency

Section 6.2.6 of the 2019 SSBC Rules states the bridge with the lowest structural cost will win in the structural efficiency category. Structural cost is also computed with equation found in Section 6.2.6 of the 2019 SSBC Rules [1].

1.2.2.7 Overall Performance

Section 6.2.7 of the 2019 SSBC Rules states the overall performance rating of a bridge is the sum of construction cost, structural cost, and any fines incurred as a violation to a team contract. The bridge achieving the lowest value of this total wins the overall the 2019 SSBC [1].

1.3 Technical Considerations

1.3.1 Structural Design

In order to compete at the 2019 SSBC the most important technical consideration to consider is the structural analysis and design of the bridge. Structural design for the bridge will include bridge type selection, member design, design of fittings, software modelling and construction drawings. These aspects must all be designed in order to meet the specifications of the 2019 SSBC Competition rules.

The bridge type will be selected in order to meet the categories of stiffness and aesthetics while maintaining lightness and overall performance. The member dimensions and design of fittings are extremely important to the construction economy of the bridge as well as the overall performance. Each individual member must not exceed the maximum dimensions of 3'-6" x 6" x 4" [1, Se. 8.2.2.2]. Each member must be capable of connecting to all adjacent members. The bridge will be modeled in Risa 3D for structural analysis.

The bridge must be designed to meet the loading requirements of the 2019 SSBC Competition Rules. In the competition there are three categories of loading. These include two vertical loads and one lateral load. Table 1 below taken from the 2019 SSBC Competition Rules shows the location of the combination of loading depending on the roll of a dice. L1 is a vertical load of 1500 pounds. L2 is a vertical load of 1000 pounds and S is a lateral load of 50 pounds.

Table 1: Combinations of Loading Locations

N	L1	L2	S
1	11'-0"	6'-0"	11'-6"
2	12'-0"	8'-0"	11'-6"
3	13'-6"	10'-0"	0'-0"
4	14'-0"	8'-4"	0'-0"
5	14'-6"	10'-8"	0'-0"
6	15'-5"	10'-5"	11'-6"

Throughout the structural design process, improvements and adjustments will be made as necessary to further improve the performance of the bridge.

1.3.2 Steel Selection

Steel selection is based on the specifications of its strength to weight ratio, durability, fabrication ability, and material availability. The grade of steel used in design should be magnetically attractive [1, Sec 8.1]. This includes members, nuts, and bolts. If violations occur; the bridge will not be ranked for awards, and loading tests are only upon approval from the judges [1, Sec 8.1].

1.3.3 Connection Design and Analysis

Connection safety is an important aspect of this AISC bridge design competition; the safety guidelines are outlined in section 9.4 of the 2019 SSBC Competition rules. Technical properties such as shear capacity, strength, steel grade etc. of the bolts, the nuts, and any other fittings, should be taken into consideration when designing connections. The AISC Steel Construction Manual will be consulted during the design and analysis of connections.

Specific fittings and connections, e.g. gusset connections and slip fitting, will be determined during the design and analysis process. These designs should operate in a way that reduces construction speed. In order to achieve a quick and competitive construction speed, the bridge members must be connected with fittings that come together easily and in a short amount of time. It would be ideal for each fitting to be self-supporting so that a member can be attached and then left alone to be bolted at a later time.

1.3.4 Fabrication

Once the design is complete, the construction drawings will be made. Drawings are needed to order material, which the team is intending to have donated. The team will utilize the services of K-Zell Metals, Inc. for laser cut precision of bridge members and connections. The team is planning to use Mingus Union High School Welding to accurately weld parts of members and connections together. Footnote of Section 8.2.2.1 of the 2019 SSBC Competition rules manual, states that only uncoated bolts and nuts should be welded for health concerns.

1.3.5 Constructability

The construction cost of the bridge is determined on the construction time, the number of builders, and load test penalties [1, Section 6.2.5]. After fabrication, the bridge should be able to assemble with ease. To be competitive, the bridge should be built under thirty minutes [1, Section 10.8.1]. If bridge construction exceeds forty-five minutes, it will not be eligible for any awards [1, Section 10.8.2]. Up to six (6) builders are allowed to construct the bridge [1, Section 10.2.2]. Maximizing builders increases construction cost. The team will determine how many builders will be needed to construct the bridge during construction practice. After constructing, the bridge is subjected to a load test.

1.4 Potential Challenges

1.4.1 Structural Modelling

It will be necessary to input and analyze the bridge design with a 2-D and 3-D modeling software i.e. Risa 2D & 3D. However, certain aspects of the bridge, i.e. fittings, will not be able to be analyzed within these software. Therefore, they must be analyzed by hand.

1.4.2 Fabrication

The most significant aspect of fabrication will be ensuring precision and accuracy. This will be difficult due to the bridge being a 1:10 scaled bridge. This means that the tolerances are significantly smaller for member lengths and connection fittings. This issue is compounded by the team’s limited access to high-precision tools and machinery. In order to maintain the required precision, most fittings and other pieces requiring high-precision will be cut and/or manufactured by K-Zell Metals. Also, due to the team’s inexperience in the field of welding, most welding will be outsourced to the Mingus High School welding team.

1.4.3 Constructability

One of the greatest challenges of this project is constructing the bridge onsite. More specifically will be constructing the bridge over the six foot wide simulated river. At no point may a builder step foot in or in any other way touch the river. This means that team members will have to coordinate and work together in order to connect the central members over the river. The preclusion of temporary piers during construction increases the difficulty of the process. This constraint further incentives the bridge to be lightweight and easy to assemble.

1.5 Stakeholders

Stakeholders for the competition includes Northern Arizona University, as the Steel Bridge Team represents the university at the competition; AISC, whom is the organizing sponsor for the competition; the client, Mark Lamer, whom is receiving the bridge; and the technical advisors, Sabrina Ballard, and Tommy Nelson, whom are dedicating their free time in order to provide the steel bridge team with professional guidance during analysis and design.

The National Park Service (NPS) is also considered a stakeholder because the proposed bridge would be constructed in the Hawaii Volcano National Park. The NPS desires more bridges to be built in the park because of the recent damage of infrastructure due to volcanic eruptions. They also want the parks to be more accessible to visitors. Engineers associated with the park will also judge the competition.

Stakeholders also include sponsors of the Steel Bridge Team. They have all contributed to the team in one way or another. They did so because they care about the success of the team and the future of the engineering workforce (aka students). Each sponsor will have their company logo printed on the team’s t-shirts. The more successful the team is at the competition, the better publicity each sponsor receives.

2.0 Scope of Services

2.1 Task 1: Project Research

2.1.1 Task 1.1 Overview of 2019 SSBC Rules & Guidelines

The team will review the rules and guidelines of the 2019 SSBC Rules & Guidelines [1]. This will be completed so the team understands that the bridge meets critical requirements. For example, vertical spacing, foundation envelope, decking envelope, connection criteria, member size, and type of steel should be provided within the 2019 SSBC Rules & Guidelines.

2.1.2 Task 1.2 Types of Steel Bridges

Having reviewed and considered the rules of competition, the team will begin reviewing various types of bridges and their corresponding geometry. From this research, the team will consider the pros and cons of each of the bridge type and then decide on which suits the criteria of competition.

2.1.3 Task 1.3 Steel Design Code Manual

The team will read and make use of pertinent sections of the Steel Design Code Manual [2]. This includes designing for connections, axial loading, shear failures, and welding methods. The team will meet with either technical advisors review general sections of the manual so that the team may effectively and accurately analyze their steel bridge.

2.2 Task 2: Resourcing

2.2.1 Task 2.1 Sponsor Outreach

To reduce the cost of fabricating the bridge, the team will contact various companies about sponsoring the team and/or donating materials. The following companies will be contacted with requests for the corresponding services: Page Steel for bulk steel donations, K-Zell Metals for precision cutting/machining of members and fittings, Copper State for nut and bolt donations, and Mingus Union High School Welding for all major welding of bridge members.

2.2.2 Task 2.2 Fundraising

To allow for the purchasing of any materials not donated, the team will need to host several fundraisers. One way this can be done is through partnerships with various restaurants in the Flagstaff area.

Any NAU student organizations can apply for funding through the Associated Students of Northern Arizona (ASNAU). NAU Steel Bridge Club is registered through ASNAU and can request funding. ASNAU grants up to $3,000 in reimbursement for the year. NAU's Student Chapter of American Society of Civil Engineers also provides $500 in limited funding to the steel bridge team. Northern Arizona University's College of Engineering, Informatics, and Applied Sciences (CEIAS), Department of Civil Engineering, Construction Management, and Environmental Engineering (CECMEE), allocates $800 to the steel bridge team through class fees.

2.3 Task 3: Structural Analysis

2.3.1 Task 3.1 Vertical Deflection Design

The main consideration during the structural analysis is the vertical deflection of the bridge under an applied load. This is because vertical deflection has the most impact on the teams score at competition. Risa 2D and Risa 3D will be used to analyze the bridge geometries (e.g. envelope, moment of inertia, member location, etc.), member sizes, and member material to calculate the aggregate deflection under the given loads of 1500 lb and 1000 lb [1, p. 34].

2.3.2 Task 3.2 Lateral Deflection Design

The bridge must be designed with enough lateral bracing so that under a 50 lb lateral load, it will deflect less than 0.5 inches, as stated in the 2019 SSBC Rules [1]. Therefore, it is necessary to determine the shape, strength, and spacing of said bracing. The bridge and its bracing will be analyzed in RISA 3D under the two loading conditions specified in the SSBC rules [1, p. 17].

2.3.3 Task 3.3 Lateral Torsional Buckling and Overturning Design

Adequate bracing/bridging must be designed within the bridge structure to prevent lateral torsional buckling and overturning. Both of these events are common occurrences in squared-end and underslung deck trusses. The bridge will be analyzed in RISA 3D under the six loading conditions specified in the SSBC rules [1, p. 17]. Bracing will be provided wherever these forces are the greatest and will be capable of resisting both tensile and compressive forces.

2.3.4 Task 3.4 Design Fittings/Connections

The fittings for each member connection must be designed separately from the bridge structure because RISA does not have the capability to model custom fittings. Each fitting must be designed to withstand the local shear and bending forces acting at that location on the bridge. This will be done using SolidWorks; a 3D modeling software. In order to focus the analysis solely on the fitting itself and to limit the sources for error, all simulated loads will be applied directly to the surface of the fitting being analyzed.

2.3.5 Task 3.5 Final Bridge Design

After all aspects of the bridge have been analyzed and designed, they will be combined and analyzed at the same time. Based on how the various components of the bridge interact with each other and how they affect the performance of the bridge, the design will be modified through an iterative process. This process will be repeated until the bridge has been optimized for efficiency and speed of construction.

2.4 Task 4: Fabrication

2.4.1 Task 4.1 Produce Construction Drawings

Construction drawings will be created in AutoCAD. They commonly include an isometric view, general plan view, elevation view, cross-section, and typical bridge details. All views show necessary dimensions and details needed for fabrication. Steel detailing includes indicating the steel grade, steel sections, as well as welding type and location. The drawings should comply with steel detailing standards specified by AISC. Andrew Lamer, with Mingus Union High School Welding, will be consulted for welding details. Consulting with Andrew Lamer will ensure that the construction drawings produced by the team clearly communicates which members are welded, also whether Andrew Lamer has any recommendations that would expedite welding. Mr. Lamer may also recommend welding placement that would effectively withstand forces applied during loading. It is also important for the team to produce construction drawings so that the team can evaluate each member complies with the 2019 SSBC Rules.

2.4.2 Task 4.2 Steel Preparation

After receiving the steel from Page Steel, the team will prepare all members for welding. This includes cutting the steel to the required lengths and angles and performing any other modifications required by the design. Welding jigs will be made to aid in the accuracy of welding pieces together. These jigs will also be used to ensure that all pieces fit together ahead of time in order to streamline the welding process.

2.4.3 Task 4.3 Welding

The team will travel to Mingus Union High School where the welding team will weld the bridge. The bridge team will supply prefabricated member jigs for the welders to use. Team members will act in a supervisory role but will not be welding. The team decided to subcontract a majority of welding members to Mingus Union Welding because the team established a relationship with them last year. Sourcing out welding to Mingus Union High School students, alleviates a massive amount of time because the bridge team does not have necessary equipment or proper training to weld the amount of steel required to make the bridge.

2.4.4 Task 4.4 Finish Fabrication

This phase of fabrication involves any work not completed during the main weld day such as cutting, drilling or grinding. This will also include welding all loose nuts to the members where needed. The Mingus Union High School Welding team will only be available for one day. Therefore, any additional work that arises or work not completed will need to be performed by the bridge team itself. Slight modifications to the bridge will likely have to be made throughout the fabrication process as well as during construction practice as the circumstances and time frame change.

2.4.5 Task 4.5 Finishing

Finishing, which includes painting, sanding, polishing, etc., will be applied to the exterior of the members. The team will also label each individual member to aid in the construction process. Any painting, sanding, or polishing will be done so that it may have a unique aesthetics compared to other bridges at competition. Sometimes the Steel Bridge and Concrete Canoes teams formulate a theme together, so this plays a factor into finishing. Labeling each member is to ensure the correct members are constructed together during practice and competition.

2.5 Task 5: Construction Practice

2.5.1 Task 5.1 Practice Assembling

The first stage of construction practice will be the build team familiarizing itself with how each member of the bridge comes together. The team will start by assembling the bridge in no specific order all the way to completion. During this process, the team will identify any potential problems surrounding the build (e.g. misaligned bolt holes) and how they should be addressed. If necessary, modifications will be made to the bridge and/or the connections.

2.5.2 Task 5.2 Optimize Construction Time

During this phase of construction practice, the team will begin trying to assemble the bridge as quickly as possible with the minimum number of builders required. Multiple sequences of construction will be tested using various methods. When a final sequence has been determined, the layout of each member in the staging areas of the build site will also be determined. Ideally a third party will be present to time the build and record any rule violations, as stated in section 10.3 and 10.4 of the rules [1]. The number and severity of rule violations may influence the sequence and method of construction.

2.6 Task 6: Project Deliverables

2.6.1 Task 6.1 Project Impacts

The 2019 SSBC provides an opportunity for students to work alongside a real-world situation by creating a scaled model of a steel bridge. Students will be given an insight into the work that is required to replace the steel bridges in Hawaii but on a smaller scale. The competition also provides valuable experience and knowledge into structural steel design as well as project management.

2.6.2 Task 6.2 Reflection Document

Each team member will deliver their own reflection document at the end of spring semester. This document will reflect each individual's thoughts and recommendations of improving this capstone (hopefully there's one).

2.6.3 Task 6.3 Website

A website will be created to document the progress of the project and will include the final documentation for the final design report, software analysis, construction drawings, competition results, team member information and any other information relevant to the project.

2.6.4 Task 6.4 30% Design Report

The team will deliver a 30% report to both grader and technical advisors so that they may provide feedback. The team will then make necessary changes from those critiques so that a 60% report will be delivered.

2.6.5 Task 6.5 60% Design Report

The team will submit any additional information and changes from the 30% report to both the grader and technical advisors. The team will then make necessary changes from those critiques so that a final design report may be prepared for the client.

2.6.6 Task 6.6 Final Design report

The final design report will be submitted to the client. The final design report will include all relevant data and results from the project from the analysis carried out, fabrication, construction, competition results and an overall reflection of the project.

2.6.7 Task 6.7 Undergraduate Research Symposium Presentation

The final presentation will be presented at the Spring Undergraduate Symposium in April, 2019. The presentation will include the design process, the fabrication, the results of the competition, and the overall success of the project.

2.7 Task 7: Project Management

2.7.1 Task 7.1 Coordination

2.7.1.1 Task 7.1.1 Travel

In order to compete at the competition, transportation to and from San Luis Obispo as well as the build site will need to be arranged for the team as well as the bridge. The team must coordinate with NAU ASCE members traveling to the PSWC competition in San Luis Obispo.

2.7.1.2 Task 7.1.2 Competition

Upon arrival at Cal Poly San Luis Obispo, the team must participate in all required activities for the competition. This includes erecting the bridge on display day and conversing with judges. The team captain must also attend the captains meeting the night before the build day. On the build day, the team must erect the bridge following all guidelines stated in section 10 of the 2019 SSBC Rules [1, pp. 25-29]. When the bridge is fully constructed, the team will proceed with the load tests described in section 11 of the 2019 SSBC Rules .

2.7.1.3 Task 7.1.3 Donations & Sponsors

When the design of the bridge is 100% complete, material orders must be placed with Page Steel and Copper State. The orders should ideally be placed before the end of the year so that the materials will arrive by the start of the spring semester.

2.7.1.4 Task 7.1.4 Volunteers & Mentees

The team will take on several mentees that have posed an interest in the Steel Bridge competition. The team will mentor and provide guidance to the mentees in regards to all aspects of the competition in order to help prepare them for future competitions.

2.7.2 Task 7.2 Budget Management

The team will reach out to Page Steel, Mingus Union Welding, K-Zell Metals, Inc., Copper State Nuts & Bolts, and several other companies. An Excel sheet will keep log of what donations and services these companies provide throughout the project. A separate Excel sheet will also be created to log man hours during the duration of the project. The team will also have to apply for ASNAU funds that will help with traveling, lodging, and competition t-shirts. In addition, AISC sponsors teams with $250 and one faculty will receive hotel reimbursement for attending the competition.

2.7.3 Task 7.3 Meetings

The team meets a minimum of 4 times this semester with both technical advisors and grader. Meeting times have not been firmly scheduled, but determining periodic meetings will be scheduled. A Gantt-Chart will be created so the client can track the progress of the project. The Gant-Chart will also be used to help the team stay on task in a timely manner. Deliverable deadlines will also be determined which include the following: Undergraduate Research Symposium presentation, website, 30% report, 60% report, and final design report. The Gantt-Chart will also include the following tasks: structural design, fabrication, and competition.

2.7.4 Task 7.4 K-Zell Metals Services

2.7.4.1 Task 7.4.1 Facility Tour

The team will take a tour of K-Zell Metals, Inc. which will be conducted on Friday November 22, at 10am. The purpose of the tour is to gain an understanding of the services that can be provided. This information will contribute to the design of member fittings in regards to what can or cannot be done.

2.7.4.2 Task 7.4.2 Plate Cutting

The team will employ the services of K-Zell Metals, Inc. for precision cutting and machining of bridge connection pieces. All designs must be submitted so that K-Zell has adequate time to produce the pieces.

2.8 Project Limitations

2.8.1 Challenges

Funding is very limited for this project and most of the materials and services are being donated by sponsors, so the extent of donations and services are up to the sponsor. The team has to limit the overall design cost of materials and services. Lastly the equipment available to fabricate and construct the bridge is extremely limited and provides an additional challenge to constructing this bridge to the highest possible standard.

2.8.2 Exclusions

The Steel Bridge Competition is limited to design and construction of structural members, joints, connections, materials and overall construction of these aspects. Excluded in the AISC 2019 SSBC are those aspects related to footings or foundations, decking and pavement, traffic analysis or utilities such as electric for street lights on the bridge.

3.0 Project Schedule

3.1 Tasks

The major tasks of this project are project research, resourcing, structural analysis, fabrication, construction practice, project deliverables, and project management. The durations of each task, as well as their associated sub-tasks, are shown in Appendix A. The duration of the project is from August 28, 2018 to May 3, 2019.

3.2 Critical Path

The critical path is highlighted in yellow within the Gantt chart (*Appendix A)*. It begins from task 1 and 2 where either task can begin without relying on any dependencies. Task 3, however, depends on subtasks in Task 1. This is the case for further tasks beyond task 3. If the team completes each subtask along the critical path, then the team should be able to complete the project on time. The team identified this critical path because it entails critical subtasks in the early stages of the project. Competition rules, structural design and analysis, fabrication, and construction practice are crucial in the completion of the bridge. The team also determined that reflection documents, or continuity letters, be the last task to complete at the end of the semester. In order to maintain an on-time project completion, the team doubled the amount of days to complete each task than normal. This method gives extra time for the team to adjust their schedule throughout the duration of the project. The critical path is maintained through setting milestones for each task and allowing time for uncertainties. The team will also habitually check the schedule for due dates.

4.0 Staffing Plan

4.1 Personnel

The project will be completed by the personnel roles listed in Table 2. Every member of the team will fulfill each role during the duration of the project.

Table 2: List of Personnel & Abbreviations

Personnel	Abbreviations
Senior Engineer	Sr.Eng
Engineer	Eng
Engineer in Training	E.I.T.
Drafter	Drf
Administration	Admin

4.2 Qualifications

The team consists of four senior level civil engineering students. Each member has unique qualifications, aside from structural analysis, to offer for this project. Below is a list of each member and their qualifications:

Kayley Adams

- Structural engineering internship (2018)
- Proficient with AutoCAD, Revit, and SolidWorks (2011-2018)
  - Experience in Tekla, Mastercam, Rhinoceros 3D
- Drafter for a steel design consultant company (2014-2015)
- Construction Coordinator – designed and built small scale projects (roofs, stairs, decks, & ramps) for a non-profit organization that fixes houses in low income communities (2016)

George Beamish

- Basic MIG/ARC welding experience
- Construction site experience
- Heavy machinery experience

Emmanuel James

- Three years of experience as a Steel Bridge Team Mentee
- Experience with RISA3D
- Construction Experience

Andrew Samson

- Two years of experience as a Steel Bridge Team Mentee
- Experience with AutoCAD, RISA 2D, and RISA 3D
- Basic MIG welding experience
- Civil Engineering major with a minor in Construction Management
- Construction experience

4.3 Plan

Table 3 shows the total amount of hours each staff member will contribute to the project along with the corresponding tasks. A full breakdown of work, including subtasks, is found in Table 6 of Appendix B. The hours for project management are high due to the long drive from Flagstaff, Arizona to San Luis Obispo, California for the AISC Steel Bridge Competition as well as overseeing the welding process at Mingus Union High school. E.I.T's are still in the learning process and therefore take longer during the design process than a more experienced engineer. The more experienced engineers delegate the smaller tasks, e.g. overviewing the fabrication process, to the E.I.T. for them to gain experience. This is why the E.I.T's hours are the highest.

Table 3: Total Hours by Task & Personnel

Task Name	Number of Hours					Total Hours
	Sr.Eng	Eng	E.I.T	Drafter	Admin	
Task 1: Project Research	6	12	18	6	8	50
Task 2: Resourcing	12	8	12	12	16	60
Task 3: Structural Analysis	30	60	75	77	30	272
Task 4: Fabrication	6	22	40	42	4	114
Task 5: Construction Practice	3	16	16	4	0	39
Task 6: Project Deliverables	13	16	30	17	25	101
Task 7: Project Management	58	56	60	46	13	233
Staff Total Hours	**128**	**190**	**251**	**204**	**96**	**869**

5.0 Cost of Services

Table 4 shows the billing rates for staff members for this project. These rates include hourly base pay rate and benefits and profit on labor. It should be noted that these rates were adjusted accordingly to median salaries of civil engineers reported in a survey conducted by the American Society of Civil Engineer (ASCE) in 2013. These billing rates also include lump overhead percentages as well as benefits. The team decided to pay staff on an hourly basis because the duration of the project does not extend above years.

Table 4: Personnel Billing Rate

Personnel	Rate ($/hr)
Sr.Eng	150
Eng	115
E.I.T.	58
Drf	40
Admin	32

The breakdown of the total cost of project services is found in Table 5. Project services does not include engineering personnel services, but rather items that are pertinent to the project. For instance, steel material, traveling cost, welder pay rate, and K-Zell cutting cost per cut. The hours calculated for welding have been considered as project management hours as we will be overseeing the welding process at Mingus Union High School (MUHS) rather than doing any of the actual welding. Therefore, the hours in the welding column imply that each personnel (i.e. Engineer, EIT, Drafter) will simply be supervising and communicating with the welders during fabrication day. This process was also included in project management because it requires coordination of materials to MUHS and schedule availability of the welders. The anticipated total costs for each personnel for the duration for entire project is found in Table 6. A more detailed breakdown of cost for each task can be found in Table 7 of Appendix B. The team will be driving from Flagstaff, Arizona to San Luis Obispo, California; to compete in the AISC Steel Bridge Competition. A trip of 1,232 miles round trip. Additionally, we anticipate K-Zell Metals to complete their services within 16 days. The company proposed the team send them construction drawings for a quote. Due to not completing this task, the team was unable to determine cost of K-Zell subcontracting services. The cost breakdown in Table 5 is an approximate cost they normally charge their customers.

Table 5: Material, & Service Cost Breakdown

Item	Cost per Unit ($/unit)	Units	# of Units	Anticipated Cost
Steel	0.5	lb	400	$ 200
Nuts & Bolts	0.1	bolt/nut	200	$ 20
Welding	60	hr	30	$ 1,800
Plate Cutting	35	cut	25	$ 875
Van Rental	60	per day	8	$ 480
Gas	0.41	mileage	1232	$ 505
Lodging	40	room/person/night	12	$ 480
			Cost of Project Services:	$ 4,360

Table 6: Anticipated Total Project Cost Summary

Item	Description	Cost per Unit ($/unit)	Units	# of Units	Anticipated Cost
Engineering Services	Senior Engineer	150	hr	128	$ 19,200
	Engineer	115	hr	190	$ 21,850
	E.I.T	58	hr	251	$ 14,558
	Drafter	40	hr	204	$ 8,160
	Admin	32	hr	96	$ 3,072
Material	Nuts & Bolts	0.1	bolt/nut	200	$ 20
	Steel	0.50	lb	400	$ 200
Travel	Van Rental	60	per day	8	$ 480
	Mileage	0.41	miles	1232	$ 505
	Lodging	40	room/person/night	12	$ 480
Subcontracted Services	Welding	60	hr	30	$ 1,800
	Plate Cutting	35	cut	25	$ 875
		Total Project Cost:			**$ 71,200**

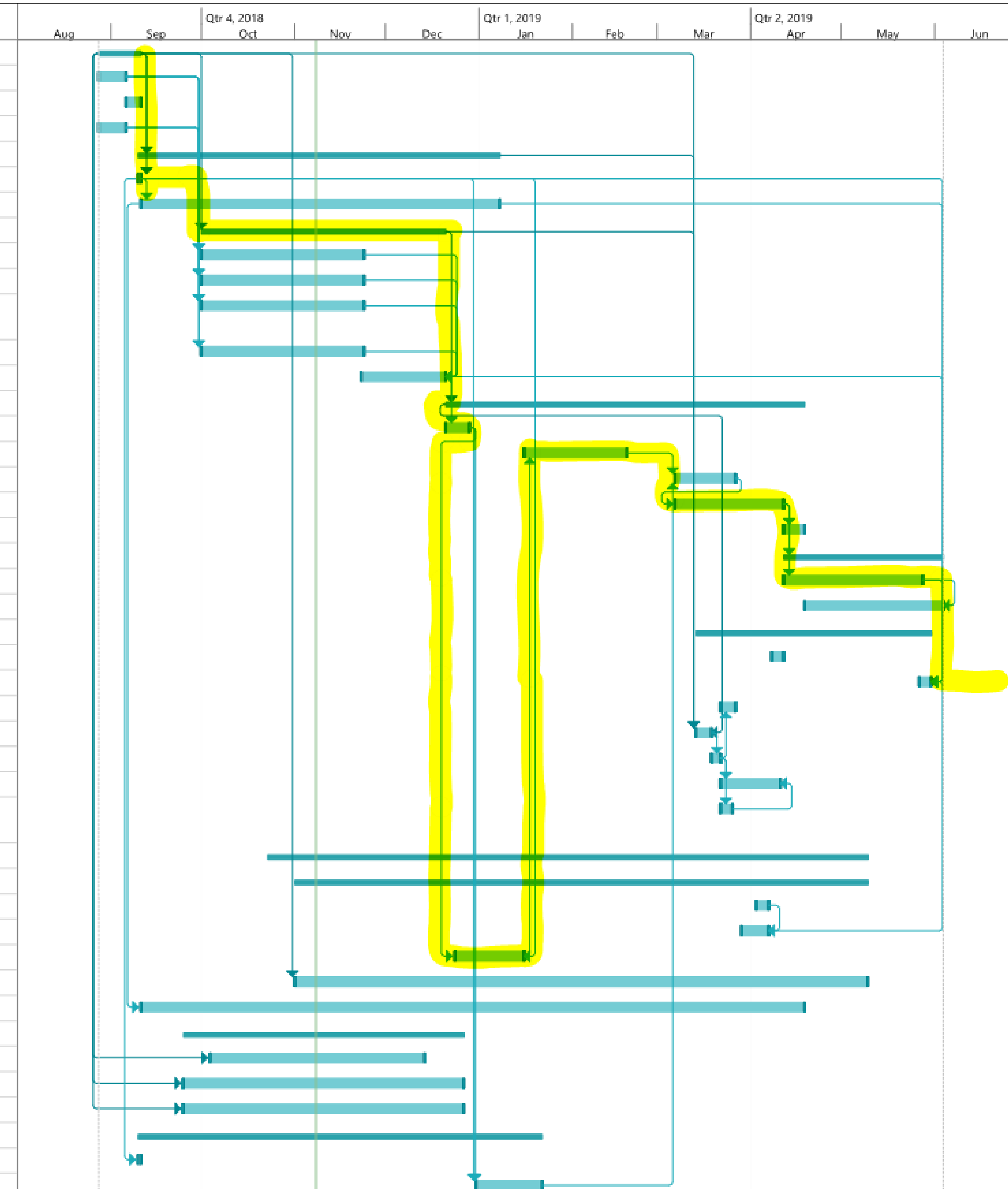
6.0 References

[1] AISC, Student Steel Bridge Competition 2019 Rules, 2019.

[2] T. B. Quimby, "A BEGINNER'S GUIDE TO THE STEEL CONSTRUCTION MANUAL, 14th ed.," 30 11 2017. [Online]. Available: http://bgstructuralengineering.com/BGSCM14/Contents.htm.

Appendix A

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**Task 1: Project Research**				
2		1.1 Overview of Rules	7 days	Tue 8/28/18	Wed 9/5/18	
3		1.2 Types of Steel Bridges	3 days	Thu 9/6/18	Mon 9/10/18	
4		1.3 Steel Design Code Manual	7 days	Tue 8/28/18	Wed 9/5/18	
5		**Task 2: Resourcing**				1
6		2.1 Sponsor Outreach	1 day	Mon 9/10/18	Mon 9/10/18	1
7		2.2 Fundraising	85 days	Tue 9/11/18	Mon 1/7/19	6
8		**Task 3: Structural Analysis**				1
9		3.1 Vertical Deflection Design	40 days	Mon 10/1/18	Fri 11/23/18	2,4
10		3.2 Lateral Deflection Design	40 days	Mon 10/1/18	Fri 11/23/18	2,4
11		3.3 Lateral Torsional Buckling and Overturning Design	40 days	Mon 10/1/18	Fri 11/23/18	2,4
12		3.4 Design Fittings/Connections	40 days	Mon 10/1/18	Fri 11/23/18	4,2
13		3.6 Final Design	20 days	Fri 11/23/18	Thu 12/20/18	9FF+6 days,10FF+6 days,11FF+6 days,12FF+6 days
14		**Task 4: Fabrication**				8
15		4.1 Produce Construction Drawings	6 days	Fri 12/21/18	Fri 12/28/18	13
16		4.2 Steel Preparation	24 days	Wed 1/16/19	Mon 2/18/19	35
17		4.3 Welding	14 days	Thu 3/7/19	Tue 3/26/19	16,44
18		4.4 Finish Fabrication	26 days	Thu 3/7/19	Thu 4/11/19	17
19		4.5 Finishing	5 days	Fri 4/12/19	Thu 4/18/19	18
20		**Task 5: Construction Practice**				18
21		5.1 Practice Assembling	32 days	Fri 4/12/19	Mon 5/27/19	18
22		5.2 Optimize Construction Time	32 days	Fri 4/19/19	Mon 6/3/19	21FF
23		**Task 6: Project Deliverables**				
24		6.1 Project Impacts	4 days	Mon 4/8/19	Thu 4/11/19	
25		6.2 Reflection Document	4 days	Mon 5/27/19	Thu 5/30/19	6FF,7FF,13FF,21FF,34FF
26		6.3 Website	3 days	Fri 3/22/19	Tue 3/26/19	28
27		6.4 30% Design Report	3 days	Thu 3/14/19	Mon 3/18/19	8,14SF,1,5
28		6.5 60% Design Report	3 days	Tue 3/19/19	Thu 3/21/19	27
29		6.6 Final Design Report	14 days	Fri 3/22/19	Wed 4/10/19	28,30FF
30		6.7 Undergraduate Research Symposium Presentation	2 days	Fri 3/22/19	Mon 3/25/19	28
31		**Task 7: Project Management**				
32		7.1 Coordination				
33		7.1.1 Travel	4 days	Wed 4/3/19	Sat 4/6/19	
34		7.1.2 Conference	7 days	Fri 3/29/19	Sat 4/6/19	33FF
35		7.1.3 Donations & Sponsors	17 days	Mon 12/24/18	Tue 1/15/19	15,6FF
36		7.1.4 Volunteers & Mentees	136 days	Thu 11/1/18	Thu 5/9/19	1
37		7.2 Budget Management	158 days	Tue 9/11/18	Thu 4/18/19	7SS
38		**7.3 Meetings**				
39		7.3.1 Technical Advisor Meetings	51 days	Thu 10/4/18	Thu 12/13/18	1SS
40		7.3.2 Client Meetings	67 days	Tue 9/25/18	Wed 12/26/18	1SS
41		7.3.3 Grader Meetings	67 days	Tue 9/25/18	Wed 12/26/18	1SS
42		7.4 K-Zell Metals Services				
43		7.5.1 Facility Tour	1 day	Mon 9/10/18	Mon 9/10/18	6SS
44		7.5.2 Plate Cutting	16 days	Mon 12/31/18	Mon 1/21/19	6,15



Project: Project Schedule
Date: Thu 11/8/18

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

Figure 1: Project Schedule and Critical Path

Appendix B

Table 6: Number of Hours & Base Billing Rate

Task Name	Number of Hours & Billable rate										Total Hours	Total Task Cost
	Senior Engineer	Billing ($/Hr)	Engineer	Billing ($/Hr)	E.I.T	Billing ($/Hr)	Drafter	Billing ($/Hr)	Admin	Billing ($/Hr)		
Task 1: Project Research	6	$150.00	12	$115.00	18	$58.00	6	$40.00	8	$32.00	50	$3,820.00
Task 2: Resourcing	12	$150.00	8	$115.00	12	$58.00	12	$40.00	16	$32.00	60	$4,408.00
Task 3: Structural Analysis	30	$150.00	60	$115.00	75	$58.00	77	$40.00	30	$32.00	272	$19,790.00
3.1 Design For Vertical Deflection	6	$150.00	12	$115.00	15	$58.00	8	$40.00	6	$32.00	47	$3,662.00
3.2 Design For Lateral Deflection	6	$150.00	12	$115.00	15	$58.00	8	$40.00	6	$32.00	47	$3,662.00
3.3 Design For Lateral Torsional Buckling and Overturning	6	$150.00	12	$115.00	15	$58.00	8	$40.00	6	$32.00	47	$3,662.00
3.4 Design Fittings/Connections	6	$150.00	12	$115.00	15	$58.00	8	$40.00	6	$32.00	47	$3,662.00
3.6 Final Design	6	$150.00	12	$115.00	15	$58.00	45	$40.00	6	$32.00	84	$5,142.00
Task 4: Fabrication	6	$150.00	22	$115.00	40	$58.00	42	$40.00	4	$32.00	114	$7,558.00
4.1 Produce Construction Drawings	2	$150.00	6	$115.00	8	$58.00	32	$40.00	0	$32.00	48	$2,734.00
4.2 Steel Preparation	0	$150.00	0	$115.00	8	$58.00	0	$40.00	0	$32.00	8	$464.00
4.3 Welding	0	$150.00	10	$115.00	10	$58.00	10	$40.00	0	$32.00	0	$2,130.00
4.4 Finish Fabrication	2	$150.00	4	$115.00	6	$58.00	0	$40.00	0	$32.00	12	$1,108.00
4.5 Finishing	2	$150.00	2	$115.00	8	$58.00	0	$40.00	4	$32.00	16	$1,122.00
Task 5: Construction Practice	3	$150.00	16	$115.00	16	$58.00	4	$40.00	0	$32.00	39	$3,378.00
Task 6: Project Deliverables	13	$150.00	16	$115.00	30	$58.00	17	$40.00	25	$32.00	101	$7,010.00
Task 7: Project Management	58	$150.00	56	$115.00	60	$58.00	46	$40.00	13	$32.00	233	$20,876.00
Staff Total Hours	128		190		251		204		96		Hours Total:	869
Staff Total Cost ($)	$19,200.00		$21,850.00		$14,558.00		$8,160.00		$3,072.00		Cost Total:	$ 66,840.00