Northern Arizona University
Department of Civil Engineering, Construction Management, and Environmental Engineering

Project Proposal

2017-2018 Northern Arizona University Steel Bridge Team

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1 INTRODUCTION

This report includes a general understanding of the Steel Bridge Project, including details pertaining to the scope of work to be performed, the project schedule, project staffing, and estimated cost.

2 PROJECT UNDERSTANDING

2.1 PURPOSE OF PROJECT

The purpose of the Steel Bridge Project is to create a 1:10 scale steel bridge that is to be used in a feasibility study for the design of a limited access, short span bridge for the Burgeon County Transportation Commission (BCTC). BCTC hopes to identify a bridge design to serve their growing populations. The bridge is meant to carry only mass transit, bicycles, pedestrians, and emergency vehicles, similar to the Portland's Bridge of the People.

The bridge is to be designed, fabricated, and constructed with respect to the given rules of the 2018 National Student Steel Bridge Competition (NSSBC). The bridges of competing schools will be judged according to stability, strength, serviceability, construction cost, construction duration, and aesthetics [1].

2.2 PROJECT BACKGROUND

2.2.1 GENERAL

The NSSBC is a competition hosted by the American Society of Civil Engineers (ASCE) and the American Institute of Steel Construction (AISC) to allow students to use structural design concepts in competition with other students across the United States. The Steel Bridge Team will compete at the Pacific Southwest Conference (PSWC) with students from California, Arizona, Nevada, and Hawaii.

This year's competition will take place at Arizona State University (ASU), and will be hosted by both ASU and Northern Arizona University (NAU). The competition will take place on April 14th, 2018, at the PSWC, where all participating universities will compete in the construction and display day competition. Placement and scoring of each bridge is to be performed as outlined in the rules described in the 2018 NSSBC Rules [1].

2.2.2 CATEGORIES OF SCORING

The scoring of the Steel Bridge will be dependent on the categories provided in the rules for the 2018 NSSBC. These categories include display, construction speed, lightness, stiffness, construction economy, structural efficiency and overall performance [1].

2.2.2.1 Display

The score related to display is dependent on a bridge appearance (balance, proportion, elegance, finish), bridge identity (university name permanently on the bridge), and a poster that will describe the design process and comply with the poster rules found in Section 6.2.1.3 of the 2018 NSSBC Rules [1].

2.2.2.2 Construction Speed

The score related to construction speed is dependent on total time used to construct the bridge, including time penalties that are described in the 2018 NSSBC Rules [1].

2.2.2.3 Lightness

The score related to lightness is related to total weight of the bridge. This weight does not include decking, tools, lateral restraint devices, or posters [1].

2.2.2.4 Stiffness

The score related to stiffness is dependent on the aggregate deflection. This deflection will be measured according to Section 11.5 of 2018 NSSBC Rules [1].

2.2.2.5 Construction Economy

The scoring for construction economy is dependent on total time in minutes, number of builders and any incurrence of load test penalties. The formula used to calculate this score is found in Section 6.2.5 of 2018 NSSBC Rules [1].

2.2.2.6 Structural Efficiency

The scoring for structural efficiency is dependent on the bridge weight, aggregate deflection, and load test penalties. The formula used to calculate this score is found in Section 6.2.6 of 2018 NSSBC Rules [1].

2.2.2.7 Overall Performance

The overall performance score is taken as the sum of structural and construction costs. The team with the lowest score achieved will be placed first in the 2018 NSSBC.

2.2.3 RULES

The rules for the 2018 NSSBC involve material and component specifications, structural specifications, functionality, usability, inspectability, construction regulations, pre-construction conditions and safe construction practices [1].

2.3 REQUIRED TECHNICAL WORK

2.3.1 STRUCTURAL DESIGN AND ANALYSIS

The Steel Bridge Team will develop the design for the bridge to be used in competition at the 2018 NSSBC. The task of designing is to include the selection of the type of bridge structure, determination of connections that will be used, selection of member sizes and shapes, as well as grades of steel that will be used in the bridge. In completion of each of these design objectives, the Steel Bridge Team will ensure that all aspects of the design adhere to the 2018 NSSBC Rules.

In accordance with the design of the bridge, the Steel Bridge Team will model and analyze the expected performance of the bridge throughout the design process, making iterations and modifications as necessary to achieve a more effective and efficient design. The Steel Bridge Team will utilize the structural modeling capabilities of RISA 3D to model the performance of the bridge.

The Steel Bridge Team will also prepare shop drawings that may be used to direct the fabrication and construction of the bridge. These shop drawings will include all dimensions and details needed to direct the fabrication and construction of the bridge. The Steel Bridge Team will use AutoCAD to prepare all shop drawings for the bridge.

2.3.2 MATERIALS RESEARCH AND SELECTION

The Steel Bridge Team will research various grades of steel that may be available for use in the construction of the bridge. The various grades of steel will be analyzed according to their material properties and their intended use within the bridge. The Steel Bridge Team will consider the cost of a given grade of steel, the availability of the steel, the strength of the steel, and the expected cross-sectional area needed for the various members of the bridge when considering the grade of steel that will be used to construct the bridge.

2.3.3 CONNECTION ANALYSIS AND TESTING

The Steel Bridge Team will perform analysis and design of all connections that will be used in the bridge and testing of critical connections. The connections will be designed to minimize slippage at joints and facilitate an efficient construction time. The joints will be analyzed with hand calculations and available computer modeling software, and various connections will be tested with the Tinius Olsen machine owned by NAU. The connections will be designed according to the results that are obtained from analysis and testing. All connections will be designed in accordance with applicable design standards.

2.3.4 FABRICATION

The Steel Bridge Team will take responsibility for the fabrication of the bridge. This may entail the Steel Bridge Team performing the fabrication by themselves, or soliciting the services of a professional welding company for necessary welding of the designed members. The Steel Bridge Team will ensure that all components of the bridge are fabricated to the appropriate

specifications. Any components that are not fabricated to the predetermined design specifications will be analyzed with respect to rule compliance, steel code compliance, and bridge functionality before being implemented or rejected.

2.3.5 CONSTRUCTION

The Steel Bridge Team will develop a strategy for completing the construction of the bridge within the allotted specifications of the 2018 NSSBC Rules and with as little time as possible. The Steel Bridge Team will decide the amount of construction workers to be used, the tools to be used, and the order in which the construction workers will assemble the various components of the bridge. After determining the construction methods, the Steel Bridge Team will practice constructing the bridge. The goal for the Steel Bridge Team will be to minimize construction errors and overall time taken to construct the bridge. The Steel Bridge Team will construct their bridge at the 2018 PSWC.

2.4 POTENTIAL CHALLENGES

The Steel Bridge Team expects to encounter challenges as they work towards the completion of this project. Some of the challenges expected are described below.

2.4.1 DESIGNING AND MODELING THE STEEL BRIDGE

The Steel Bridge Team anticipates encountering challenges while designing the bridge and modeling in RISA 3D, a structural modeling software. The Steel Bridge Team has little experience using RISA 3D to model structural systems.

Additionally, no one on the Steel Bridge Team has taken a course in structural steel design, and therefore the Steel Bridge Team will need to learn about structural steel design in order to create a structurally efficient and rapidly constructible design. The Steel Bridge Team anticipates the need to obtain help from online resources, technical advisors, and other resources to aid them in the design process for the bridge.

2.4.2 CONNECTIONS

Connections will be a vital component in the design of the bridge. The connections will have a large impact on both the structural efficiency and constructability of the bridge. The Steel Bridge Team expects that it will be a challenge to design connections that are not only strong but that may be constructed quickly. Slippage at the connections will greatly affect the deflection of the bridge under loading, therefore it will be important for the connections to provide a sufficient amount of stiffness. However, the stiffness provided by the connections must be balanced with the efficiency with which the connections may be constructed.

2.4.3 FABRICATION

The Steel Bridge Team is knowledgeable of the fact that fabrication will require a large amount of time in the project schedule. In addition to time, the Steel Bridge Team anticipates having a challenge in slippage in connections between members. In the past, deflections calculated in RISA

3D have been less than the actual deflection measured in competition. With this challenge in mind, the Steel Bridge Team plans to account for uncertainties caused by imperfections in fabrication. This will be accomplished by in-house testing of materials, clear and detailed drawings, and thoughtful consideration of the design of connections in RISA 3D.

2.5 STAKEHOLDERS OF PROJECT

The stakeholders of this project include Northern Arizona University, Mark Lamer, Thomas Nelson, the Burgeon County Transportation Commission, and the American Society of Civil Engineers. The complete list of stakeholders is as follows:

- Northern Arizona University (student representation): Northern Arizona University (NAU) is a stakeholder because the 2018 Steel Bridge Team is directly representing NAU.
- Mark Lamer (client): Mark Lamer is a stakeholder to the project because he is the one who directly receives the proposed bridge design for consideration.
- Thomas Nelson (technical advisor): Thomas Nelson is a stakeholder to the project because his technical advice will directly influence the final proposed design and how the bridge performs will reflect the advice he provides.
- BCTC (competition beneficiary): Burgeon County Transportation Commission is a stakeholder to the project because the design will directly go towards the feasibility test that will be conducted by BCTC to identify the best design for a limited access, short-span bridge.
- ASCE (competition host): ASCE is a stakeholder to this project because it hosts the conference at which the competition will take place and is one of the two organizations that sponsors and facilitates the NSSBC.
- AISC (competition host): AISC is a stakeholder to this project because it is one of the two organizations that sponsors and facilitates the National Student Steel Bridge Competition. It is involved with organizing the competition and creating the rules that govern the competition.
- Co-sponsors of the NSSBC: The co-sponsors of the NSSBC are American Galvanizers Association (AGA); Bentley Systems, Inc.; Canadian Institute of Steel Construction (CISC); DS SolidWorks Corp.; James F. Lincoln Arc Welding Foundation; National Steel Bridge Alliance (NSBA); Nucor Corporation.

3 PROJECT SCOPE

The following sub-sections describe breakdown of tasks for the Steel Bridge Project.

3.1 TASK 1: RESEARCH

In order to decide upon different aspects of the bridge such as connections, cross-sections, and bridge truss type, the Steel Bridge Team will use various literature sources to gain background as well as RISA 3D structural analysis software to model considered structural systems. AutoCAD will be used to display design details. In order to fully research the connections, the

Steel Bridge Team will test the strength of vital connections using the Tinius Olsen machine owned by NAU.

Before detailed members and connection design is started, technical advisors, Thomas Nelson and Sabrina Ballard, will be contacted in order to discuss the prior team's successes, failures, and other design considerations that would best benefit the Steel Bridge Team. This information will be taken into account in order to design and test different connection types. Once the most effective connection systems are determined, the connections will be designed using hand calculations.

3.2 TASK 2: FUNDRAISING

To help obtain the necessary funding and materials required for fabrication and competition at the (PSWC) in 2018, the Steel Bridge Team will complete all necessary fundraising for materials, services, and monetary donations.

3.3 TASK 3: ANALYSIS

In order to ensure the most efficient bridge design is selected, several preliminary alternatives will be modeled and scored through the use of the official NSSBC scorecard. During this preliminary state of analysis, RISA 2D and necessary hand calculations will be utilized to evaluate the structural performance of the preliminary designs. The NSSBC scorecard will then provide quantitative feedback on aspects of the bridge such as material selection, complexity of connections, number of members, lightness, complexity of design, and load bearing capabilities.

Upon selection of bridge geometry, RISA 3D will be used to analyze the deflections and load bearing capabilities of the complete bridge structure. During this process, the values that are put into the NSSBC scorecard will continue to be updated to reflect accurate scoring. Physical testing of the connections and provided steel materials are to be completed within the NAU Engineering Materials Lab with access to the university's Tinius Olsen machine. The RISA 3D model of the bridge will continuously be updated and analyzed to reflect changes throughout the design process.

3.3.1 TASK 3.1 MEMBER ANALYSIS

Members will be designed according to the 2018 NSSBC competition rules and the expected loads that will be imposed on the bridge. Each of the possible load cases will be considered in the analysis and design of the bridge, as well as the loading that will be encountered by the bridge during intermittent phases of loading while the bridge is being loaded at PSWC, i.e. when the first half of loading is applied.

3.3.2 TASK 3.2 CONNECTION ANALYSIS

All connections in the bridge will be analyzed according to computer software, hand calculations, and testing, as applicable. The analysis and testing of the connections will inform the design of the connections that will be used in the bridge.

3.3.3 Hand Calculations

Hand calculations will be required for the analysis of the design of the connections. The hand calculations will be completed according to the appropriate code design standards for the type of steel being used. Hand calculations for connections will be performed using the AISC Steel Construction Manual and the AISI North American Specification for Design of Cold-Formed Steel Structural Members.

3.4 Task 4: Fabrication

3.4.1 Task 4.1: Member Preparation

The design of all connections and members is to be completed prior to construction, including all sizing and preparation tasks. Additionally, the Steel Bridge Team will perform all required drilling, cutting, grinding, and related tasks to prepare the members for construction. All steel to be welded will be prepared by the time a professional welding company will come to weld the bridge.

3.4.2 Task 4.2: Professional Welding

In order to expedite the fabrication process and ensure quality is upheld, a professional welding team will be subcontracted onto the project to complete the welding process.

3.5 Task 5: Construction

The construction plan developed for the project will adhere to the standards set forth within the 2018 NSSBC Rules document, as well as to the applicable standards established within the Accelerated Bridge Construction (ABC) Design Guidelines published by the Federal Highway Administration [2]. Construction of the bridge will be practiced under conditions as close as possible to that of the PSWC 2018 competition.

3.6 Task 6: Competition

In April 2018, the Steel Bridge Team will compete at the PSWC. The PSWC will take place at Arizona State University on April 12th through April 14th, 2018. The PSWC is where the Steel Bridge Team will construct their bridge for competition and be scored according to the categories outlined in the NSSBC and in Section 2.2.2.

3.6.1 Task 6.1: Transportation

The Steel Bridge Team will transport their finished bridge in a carrying case that has the capacity to hold all members. This carrying case will then be placed in the back of the Northern Arizona University College of Engineering, Forestry, and Natural Sciences trailer and driven to the PSWC in Tempe, Arizona. At the PSWC, the Steel Bridge Team will transport the bridge as needed.

3.6.2 TASK 6.2: DISPLAY

The Steel Bridge Team will present a poster at the PSWC that illustrates the work completed to design the bridge. The components of the poster will include university identification, explanation of the choice of bridge configuration, dimensioned view of the bridge, free body diagram, shear force diagram, bending moment diagram, provisions for Accelerated Bridge Construction (ABC), and acknowledgement of all help received.

3.6.3 TASK 6.3: CONSTRUCTION

When at the PSWC, the Steel Bridge Team will construct their bridge on the last day of the competition (April 14th, 2018). The construction crew for the bridge will consist of 2-6 NAU students and will occur at the specified bracket that NAU will be placed in. The construction crew will construct the bridge and then await the loading process to continue the competition.

3.6.4 TASK 6.4: LOADING

Once the Steel Bridge Team constructs their bridge, two different loading tests will occur. The first loading test is the lateral load test. The lateral load test will be conducted as a 75 pound vertical force applied at a specified distance with a 50 pound lateral load applied at that same distance. The Steel Bridge Team's bridge must deflect less that one inch.

The vertical load test is conducted by three members applying the specified load onto the bridge on the provided decking units. The total amount of weight that is distributed onto the bridge is 2500 pounds. If the bridge creates imminent threat of failure or deflections exceed the maximum, the judge has the right to inform the Steel Bridge Team to step away and not continue to load the bridge.

3.6.5 TASK 6.5: SCORE REPORTING

At the conclusion of the competition at the PSWC, the Steel Bridge Team will await the final results that will be posted on both the host team of the PSWC and the NSSBC website. The score report will include categories such as lightness, stiffness, display, construction speed, construction economy, structural efficiency and overall performance. All scores from competition are not considered final until scores are officially posted.

3.7 TASK 7: DISPLAYING RESULTS

The Steel Bridge Team will present the results of the bridge design and of the Steel Bridge Team's performance at the PSWC. These results will inform others about the significance and relevance of the project, and will help others to understand engineering and the engineering design process better. The results will be displayed by a presentation at the 2018 Undergraduate Research and Design Symposium (UGRADS), a final design report, detailed AutoCAD drawings of the final design, and a website to document the project.

3.7.1 Task 7.1: Northern Arizona University Undergraduate Research and Design Symposium

The Steel Bridge Team will participate in the UGRADS during the Spring 2018 semester at NAU. This will involve giving a presentation about the completed project to various engineering faculty, students, and others. The presentation will describe the design, fabrication, construction, and competition aspects of the project. The Steel Bridge Team will discuss the significance and relevance of our project in terms of engineering.

3.7.2 Task 7.2: Final Design Report

The final design report will document the various stages of the Steel Bridge Project. This will include the project scope, the analyses performed by the Steel Bridge Team, the design decisions made, the fabrication process, the construction strategy, the competition results, and discussion and reflection on the project. The report will include relevant data and results obtained from the analyses performed.

3.7.3 Task 7.3: Construction Drawings

The Steel Bridge Team will create construction drawings of the final bridge design. These drawings will be used to document the final design and guide the fabrication and construction of the bridge. The drawings will include all relevant details needed to guide the fabrication and construction of the bridge.

3.7.4 Task 7.4: Website

The Steel Bridge Team will create a website that will include documentation of the project including the final design report, final drawings, competition results, pictures, and other relevant aspects of the project. The website will be created according to guidelines outlined by the grading instructor of the class.

3.8 Task 8: Project Management

The Steel Bridge Team will oversee all aspects of project management for the project. This will include communication, scheduling, and budgeting.

3.8.1 Task 8.1: Meetings

Project management and progress meetings will be required in order to ensure work is progressing in a timely manner. Meetings will be open to the client, technical advisors, sponsors, and faculty grading instructors when necessary. All communication with these individuals and groups will be organized and handled by the Steel Bridge Team.

A 50% report is to be prepared and reviewed with the client. Additionally, 60% shop drawings shall be reviewed with the client and technical advisor prior to approval for construction. Upon completion of the project, a reflection document shall be developed and reviewed with the faculty grading instructor in order to provide feedback and concern.

3.8.2 TASK 8.2: SCHEDULING

The Steel Bridge Team will create a schedule for their project to ensure that all deliverables are completed on time. Some major items to be included in the schedule are design and analysis of the bridge, fabrication of the bridge, practicing construction of the bridge, and competing at the PSWC. The Steel Bridge Team will consider the expected amount of time required for each of these items and create the schedule considering the overall time constraints of the project.

3.8.3 TASK 8.3: BUDGETING

The Steel Bridge Team will create and oversee a budget for the Steel Bridge Project. The Steel Bridge Team will oversee that the project is completed according to the budget. The Steel Bridge Team will work to be resourceful and economical. The Steel Bridge Team will also estimate the amount of money that would be spent on labor and service costs, though the Steel Bridge Team will not be paid for the completion of the project.

3.9 PROJECT LIMITATIONS

The Steel Bridge Team agrees to complete all items included in this document. If the client thinks that any items are missing from this document, they may request the Steel Bridge Team to revise the necessary project scope.

3.9.1 CHALLENGES

The Steel Bridge Team expects to encounter challenges while modeling in RISA 3D, fabricating the bridge, and in setting and keeping a schedule. The Steel Bridge Team will face these challenges by asking questions to their various advisors, referencing available resources, and by consistently meeting as a team weekly at the minimum.

3.9.2 EXCLUSIONS

The Steel Bridge Team will complete only the structural, fabrication, and construction components of the Steel Bridge Project. This will be limited to connection design, member design, material selection, fabrication and the construction processes. The Steel Bridge Team will not be responsible for aspects of the bridge involving lighting, footings, transportation impact analysis, or pavement across the bridge.

3.10 PROJECT IMPACTS

The Steel Bridge Project will contribute to the furthering of the education of the students involved in the project. Students involved in the project will gain valuable insights and experience in structural steel design. Students will have the opportunity to perform structural analysis and design and gain experience in steel fabrication and construction. In addition, students will familiarize themselves with concepts of cost efficiency in relation to structural design and construction.

4 PROJECT SCHEDULE

The proposed schedule for the 2018 Steel Bridge Project is as shown in Table 4-1. The Gantt chart that will be used to guide the project is included in Appendix A.

Table 4-1: Steel Bridge Project Schedule

Task	Begin date	End date	Duration
Task 1: Research	**9/5/2017**	**4/12/2018**	**220**
Steel Design	9/5/2017	12/22/2017	109
Steel Fabrication	1/16/2018	3/13/2018	57
Construction Methods	3/14/2018	4/12/2018	30
Task 2: Fundraising	**12/22/2017**	**4/5/2018**	**105**
$500 Raised Total	12/22/2017	12/22/2017	
$1000 Raised Total	1/15/2018	1/15/2018	
$2000 Raised Total	4/6/2018	4/6/2018	
Task 3: Analysis	**9/19/2017**	**12/21/2017**	**94**
Preliminary Analysis	9/19/2017	11/6/2017	49
Preliminary RISA Modeling	9/19/2017	11/6/2017	49
Preliminary Connection Design	10/15/2017	11/5/2017	22
Preliminary Material Selection	10/15/2017	11/5/2017	22
Scoring and Selection	11/7/2017	11/7/2017	
Final Design	11/7/2017	12/21/2017	45
Final RISA Model	11/7/2017	12/21/2017	45
Member Design Details	11/7/2017	11/20/2017	14
Connection Design Details	11/21/2017	12/21/2017	31
Place Steel Order	12/22/2017	12/22/2017	
First Draft of Shop Drawings Complete	12/23/2017	12/23/2017	
Winter Break	12/22/2017	1/14/2018	24
Task 4: Fabrication	**1/15/2018**	**3/13/2018**	**58**
Preparation	1/15/2018	2/12/2018	29
Member Preparation	1/15/2018	2/1/2018	18
Cutting and Drilling	2/2/2018	2/12/2018	11
Welding	2/13/2018	2/14/2018	2
Finish Fabrication	2/13/2018	3/13/2018	29
Task 5: Construction Practice	**3/14/2018**	**4/13/2018**	**31**
Task 6: Competition	**4/13/2018**	**4/15/2018**	**3**
Competition Poster Preparation	3/26/2018	4/13/2018	19
Task 7: Displaying Results	**3/19/2018**	**4/29/2018**	**42**
Project Design Report	3/19/2018	4/29/2018	42
Project Website	4/16/2018	4/29/2018	14
NAU UGRADS Presentation	4/27/2018	4/27/2018	1

(Continued on next page.)

Table 4-2: Steel Bridge Project Schedule (continued)

Task 8: Project Management	**9/21/2017**	**4/25/2018**	**217**
Course Deliverables	9/5/2017	12/14/2017	101
Background Research	9/5/2017	9/14/2017	10
Project Understanding	9/11/2017	9/20/2017	10
First Draft Project Scope	9/20/2017	10/17/2017	28
Scope and Scheduling	10/17/2017	10/31/2017	15
Staffing	11/1/2017	11/9/2017	9
Webpage	11/13/2017	11/30/2017	18
Reflection	12/4/2017	12/7/2017	4
Final Proposal	11/27/2017	12/14/2017	18

5 STAFFING AND COST OF ENGINEERING SERVICES

This section describes the qualifications of the Steel Bridge Team and the anticipated man-hours and expenses that will be required for this project. All values that are included in this document are meant to be taken as an estimate and are subject to change.

5.1 STATEMENT OF QUALIFICATIONS

The members of the 2017-2018 NAU Steel Bridge Team are Ian Connair, Taylor Erdmann, Matt Parrish, and Isaac Block. All members of the Steel Bridge Team are senior civil engineering students at Northern Arizona University. The following lists outline the qualifications of each member that pertain to the Steel Bridge Project.

5.1.1 ISAAC BLOCK

- Successful completion of Structural Analysis I & II, and Mechanics of Materials
- Some experience in RISA 2D and RISA 3D
- AutoCAD experience
- Microsoft Word, Excel, and PowerPoint experience

5.1.2 IAN CONNAIR

- 2016-2017 Steel Bridge Mentee
- Successful completion of Structural Analysis I & II, and Mechanics of Materials
- Proficient in AutoCAD
- Familiarity with RISA 2D
- Microsoft Office Experience

5.1.3 TAYLOR ERDMANN

- 2016-2017 Steel Bridge Mentee
- Successful completion of Structural Analysis I & II, and Mechanics of Materials
- Proficient in AutoCAD
- familiarity with RISA 2D
- Experience in Microsoft Word, Excel, and PowerPoint

5.1.4 MATTHEW PARRISH

- 2016-2017 Steel Bridge Mentee
- Successful completion of Structural Analysis I & II, and Mechanics of Materials
- Some experience with Microsoft excel, and RISA 2D
- AutoCAD experience
- Structural Design Internship experience
- Familiarity with AISC Steel Manual

5.2 DIVISION OF LABOR

Table 5-1 identifies all staff positions that will complete work on this project. Each position has been assigned an appropriate abbreviation for reference throughout this section of the document. The billing rate for each position is provided as well. See Table 5-2 for how billing rates were determined.

Table 5-1: Project Team Positioning

Staff Member	Abbreviation	Rate ($/hr)
Principle Engineer	PRE	175
Project Engineer	PJE	135
Project Manager	PM	150
Engineer in Training	EIT	75
Intern	INT	45
Administration	ADM	60
Drafter	DRF	60

Sub-sub-sections 5.2.1 – 5.2.7 describe the roles of each position shown in Table 5-1.

5.2.1 PRINCIPLE ENGINEER (PRE)

The principle engineer will provide the final check on all milestones before progression of the project will continue. This will involve reviewing reports, design details, and calculations. The principle engineer will be present during all meeting critical to the progress of the project.

5.2.2 PROJECT ENGINEER (PJE)

The project engineer will oversee the progress of the project at all stages of development. This will involve being involved in the analysis and fabrication of the bridge but will not be present in meetings.

5.2.3 PROJECT MANAGER (PM)

The project manager will ensure that the project stays on schedule and within budget and will oversee the fundraising for the project. This will involve monitoring the progress of analysis and fabrication and contacting various companies to request funds, materials, and services.

5.2.4 ENGINEERS IN TRAINING (EITS)

The EITs will perform a majority of the analysis and fabrication required for the project. The EITs will also perform fundraising alongside the project manager and research alongside the interns. EITs will frequently attend meetings, go to the PSWC competition, and will compile a final design report, redline shop drawings, and create a project website.

5.2.5 INTERNS (INT)

Interns will perform a majority of the fundraising and research for the project and will help the engineers in training with the fabrication of the bridge and at the PSWC competition. Interns will also frequently attend meetings.

5.2.6 ADMINISTRATIVE (ADM)

The administration will ensure that the scheduling and budgeting are complete for the project.

5.2.7 DRAFTER (DRF)

The drafters will create a set of shop drawings of the bridge. The shop drawings will guide the fabrication and construction of the bridge.

5.3 ESTIMATED PROJECT COST

This sub-section describes the estimated cost of the Steel Bridge Project.

Table 5-2 shows a breakdown of the staff rate values in terms of the company's expenses and profit.

Table 5-2: Staff Rate Breakdown

Staff	Pay Rate ($/hr)	Overhead ($/mnth)	Rent ($/mnth)	Software License ($/year)	Benefits ($/yr)	Profit ($/hr)	Rate ($/hr)
Principle Engineer	$65.00	$40.00	$125.00	$1,550.00	$4,056.00	$82.39	$150.00
Project Engineer	$45.00	$40.00	$125.00	$1,550.00	$2,808.00	$87.82	$135.00
Project Manager	$35.00	$40.00	$125.00	$1,550.00	$2,184.00	$138.03	$175.00
Engineer in Training	$25.00	$40.00	$125.00	$1,550.00	$1,560.00	$48.25	$75.00
Intern	$15.00	$40.00	$125.00	$1,550.00	$936.00	$28.46	$45.00
Welding Technician	$35.00	$40.00	$125.00	$1,550.00	$2,184.00	$38.03	$75.00
Admini-stration	$18.00	$40.00	$125.00	$1,550.00	$1,123.20	$40.40	$60.00
Drafter	$22.00	$40.00	$125.00	$1,550.00	$1,372.80	$36.31	$60.00
Total		**$320.00**	**$1,000.00**	**$12,400.00**	**$16,224.00**	**$499.70**	

The overhead was calculated as the expected office utility costs distributed among the staff members. The rent was calculated as the average office rent distributed among the staff members. The cost of four software licenses for both RISA-3D and AutoCAD were distributed among the staff members. Benefits were determined as 3% of an employee's base pay rate. Profit was determined based on the company's desired profit from each staff member to meet the company profit goals.

Table 5-3 displays the expected hours that each staff member will spend on each individual project task. Additionally, the cumulative number of hours that will be spent on each task and the total hours required for the overall completion of the project are displayed. A total of 728 hours are projected for the completion of the Steel Bridge project. The project is expected to cost a total of about $54,800 in labor costs.

Table 5-3: Estimated Project Hours and Labor Costs

Task	Number of Hours Anticipated							Task Total Hours	Task Total Cost ($)
	PRE (1)	PJE (1)	PM (1)	EIT (4)	INT (4)	ADM (1)	DRF (1)		
1: Research	1		2	10	20			**33**	$ 2,125.00
2: Fundraising			2	2	4			**8**	$ 630.00
3: Analysis	6	6	6	160				**178**	$14,760.00
3.1: Member Analysis	2	2	2	50				56	$ 4,670.00
3.2: Connection Analysis	2	2	2	50				56	$ 4,670.00
3.3: RISA Model	2	2	2	60				66	$ 5,420.00
4: Fabrication	3	7.5	6	100	40			**156.5**	$11,737.50
4.1: Member Preparation	1	2.5	2	40	20			65.5	$ 4,712.50
4.2: Connection Preparation	1	2.5	2	40	20			65.5	$ 4,712.50
4.3: Professional Welding	1	2.5	2	20				25.5	$ 2,312.50
5: Construction Practice	1	10	2	30	20			**63**	$ 4,975.00
6: Competition	3			28	38			**69**	$ 4,335.00
6.1: Transportation	0.5			24	24			48.5	$ 2,967.50
6.2: Display	0.5				4			4.5	$ 267.50
6.3: Construction	1			4	4			9	$ 655.00
6.4: Loading	0.5				4			4.5	$ 267.50
6.5: Score Reporting	0.5				2			2.5	$ 177.50
7: Displaying Results	3			51	2		7.5	**63.5**	$ 4,890.00
7.1: UGRADS				12				12	$ 900.00
7.2: Final Design Report	1			20				21	$ 1,675.00
7.3: Drawings	2			7.5			7.5	24.5	$ 1,925.00
7.4: Website				4	2			6	$ 390.00
8: Project Management	8		11	64	64	2	8	**157**	$11,330.00
8.1: Meetings	4		4	64	64		8	144	$ 9,460.00
8.2: Scheduling	2		5			1		8	$ 1,160.00
8.3: Budgeting	2		2			1		5	$ 710.00
Staff Total	25	23.5	29	437.5	188	2	23	**Total Hours:**	**728**
Staff Total Cost ($)	$4,375.00	$3,172.50	$4,350.00	$32,812.50	$8,460.00	$120.00	$1,380.00	**Total Cost:**	**$54,670.00**

Table 5-4 shows the estimated breakdown of material and service costs.

Table 5-4: Cost of Services

Item	Cost per Unit ($/unit)	Units	# Units	Cost
Total Personnel Cost	-	-	-	$54,700
Steel Members [4]	1.25 (avg.)	Lineal foot	250	$313
Steel Plate [4]	4	Square feet	8	$32
Material Testing	100	hours	5	$500
Welding	70	hours	8	$560
Van Rental	80	day	4	$320
Van Mileage	0.125*	mile	300	$50
Lodging	30	room/person/night	12	$360
Total				**$56,800**

* Assuming 15 mpg fuel efficiency for van and gas price of $2.50 per gallon.

As shown in Tables 5-3 and 5-4, the total estimated cost of the Steel Bridge Project is approximately $56,800.

6 CONCLUSION

The Steel Bridge Team proposed the schedule and budget described in this report for the Steel Bridge Project. The Steel Bridge Team will assume responsibility for all tasks included in this report. It is anticipated that a total of about 728 man-hours will be required with a principle engineer, a project engineer, a project manager, EITs, interns, an administrative assistant, and a drafter working towards the completion of the project. The anticipated cost of the project is $56,800, accounting for labor, steel materials, material testing, and transportation and lodging.

7 REFERENCES

[1] Student Steel Bridge Competition 2018 Rules, 1st ed., ASCE / AISC, 2017.
[2] Federal Highway Administration, “Accelerated Bridge Construction Manual, USDOT, 2017.
[3] S. Ballard, S. Hopper, R. Morofsky, M. Stevens, “Final Design Report,” 2017.
[4] MetalsDepot [Online]. Available: https://www.metalsdepot.com/steel-products/

APPENDIX A: PROJECT SCHEDULE GANTT CHART

Name	Begin date	End date
Task 1: Research	9/5/17	4/12/18
Steel Design	9/5/17	12/22/17
Steel Fabrication	1/16/18	3/13/18
Construction Methods	3/14/18	4/12/18
Task 2: Fundraising	12/22/17	4/5/18
$500 Raised Total	12/22/17	12/22/17
$1000 Raised Total	1/15/18	1/15/18
$2000 Raised Total	4/6/18	4/6/18
Task 3: Analysis	9/19/17	12/21/17
Preliminary Analysis	9/19/17	11/6/17
Final Design	11/7/17	12/21/17
Place Steel Order	12/22/17	12/22/17
First Draft of Shop Draw...	12/23/17	12/23/17
Winter Break	12/22/17	1/14/18
Task 4: Fabrication	1/15/18	3/13/18
Preparation	1/15/18	2/12/18
Welding	2/13/18	2/13/18
Finish Fabrication	2/13/18	3/13/18
Task 5: Construction Pra...	3/14/18	4/13/18
Competition Poster Pre...	3/26/18	4/13/18
Task 6: Competition	4/14/18	4/14/18
Task 7: Displaying Results	3/19/18	4/29/18
Project Design Report	3/19/18	4/29/18
Project Website	4/16/18	4/29/18
NAU UGRADS Presen...	4/27/18	4/27/18
Task 8: Project Manage...	9/21/17	4/25/18
Course Deliverables	9/5/17	12/14/17
Background Research	9/5/17	9/14/17
Project Understanding	9/11/17	9/20/17
First Draft Project Sc...	9/20/17	10/17/17
Scope and Scheduling	10/17/17	10/31/17
Staffing	11/1/17	11/9/17
Webpage	11/13/17	11/30/17
Reflection	12/4/17	12/7/17
Final Proposal	11/27/17	12/14/17

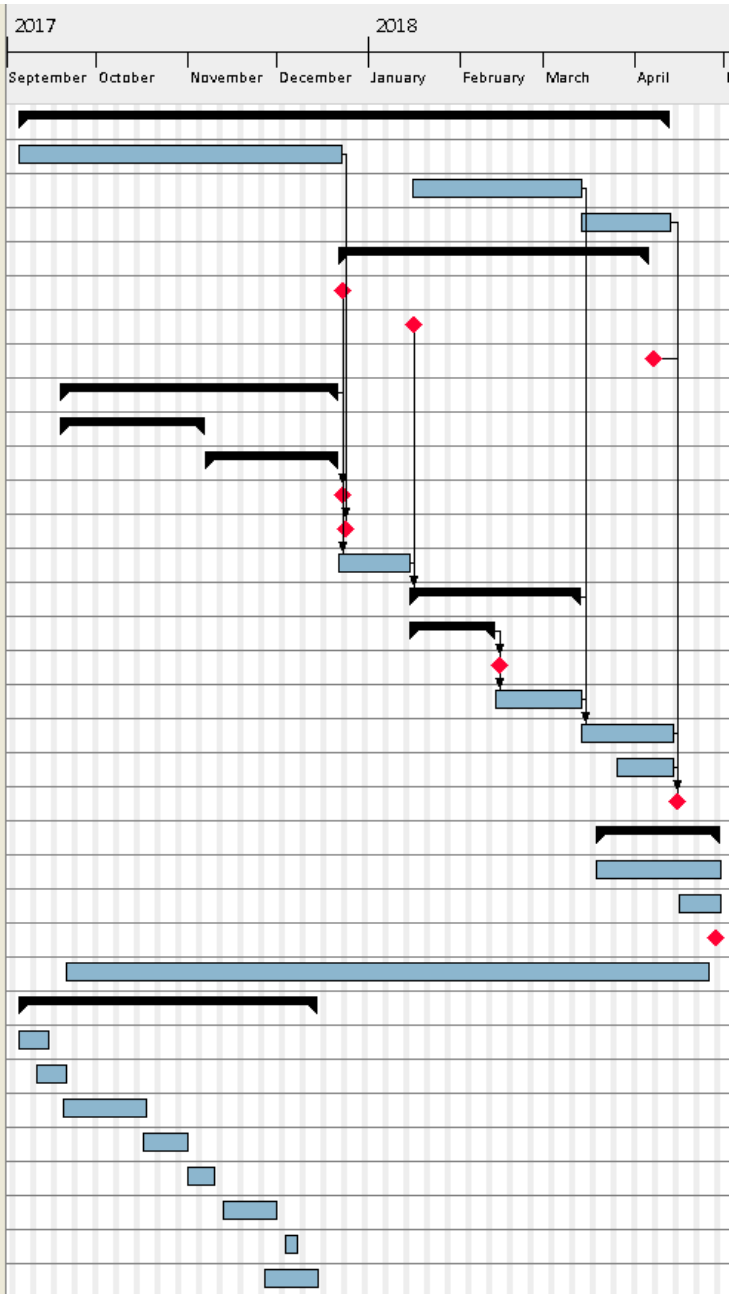

Figure A-1: Project Schedule Gantt Chart