AISC/ASCE Student Steel Bridge Competition

A Technical Report submitted to the Department of Civil and Environmental Engineering

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Zoe DeGuzman

Spring, 2025

Technical Project Team Members

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Bear Matheson

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Ben Van Zandt

Eric Venner

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Jose Gomez, Department of Civil and Environmental Engineering

Design Report

Davenport, DeGuzman, Matheson, Sadler, Van Zandt, Venner

Introduction

Design Problem Statement

Our 4th year Civil Engineering Capstone group is tasked with reviving the dormant UVA ASCE Steel Bridge Competition team. The ASCE Steel Bridge Competition provides a fictional problem statement for which the bridge model is meant to be a solution. For 2025, the ASCE has provided details about bridging the Skunk River Water Trail.

The Skunk River Water Trail was initially formed by a glacial melt, which provides a river corridor that runs through Story County, Iowa. It has historical uses since the late 1800's of powering saw and grist mills and is now managed by the Story County Conservation. The river runs through Peterson Park, which has unique and longstanding natural habitats and aquatic wildlife in the river and on a river island sandbar. The park wants to better connect trails while appealing to Story County Conservation environmental standards. Thus, our technical problem is: "How do we improve the trail connections in Peterson Park while navigating the South Skunk River and leaving its wildlife undisturbed?"

Design Objectives

The main constraint of the problem is that the solution must be a steel bridge. Our team has designed and will construct a steel bridge that adheres to the following constraints: The maximum height of the bridge is 3'-0" above the ground. The height of the stringer must be 1'-7" to 1'-11" excluding the height of the footing. The width of the bridge must be between 3'-6" and 5'-0". The minimum vertical clearance must be 0'-7" above the ground. The span length of the North side stringer must be between 15'-6" and 16'-6". The span length of the South side stringer must be between 20'-0" and 21'-0". Each individual member cannot exceed the dimensions of 3'-6" x 0'-6" x 0'-4". The maximum horizontal separation between stringer members is ¼". The maximum elevation difference along a stringer is 1/8".

Within these constraints, the team has iteratively worked through our design to optimize structural efficiency, constructability, cost, and aesthetics of the bridge. Through analysis using structural design software (Revit, RAM), the team has minimized the deflection of the bridge by increasing its load capacity while limiting the weight, cost, and speed of construction of the bridge. By testing different member types and configurations, the best member options were selected. Aesthetics were considered by selecting the best member shapes, configurations, and paint designs to make the bridge visibly pleasing without impacting efficiency.

The team has purchased the material to be used for the final construction of the bridge and is awaiting delivery. The team will ensure an efficient connection method through practice in Lacy Hall. The team has been practicing the welding and other fabrication equipment before fabrication of the final construction material takes place. In preparation for the competition, the team will plan and execute multiple runs of construction to improve the method and efficiency of construction at the competition.

Holistic Goals

The primary goal of our capstone was to fabricate the bridge to be built based on our model and within the constraints of the competition to carry the required load. With this, we hope to have a tangible display that can represent the work of Civil Engineers at UVA. Completion of this goal is determined if the group can construct and present the bridge at the capstone presentation at the end of the Spring 2025 semester.

The secondary goal was to compete at the ASCE Steel Bridge Competition. This was a lofty goal based on the time constraints of the project, which is why this was our secondary goal. This goal will be achieved if the team attends and competes at the March ASCE Symposium.

The final goal of this capstone is to leave the legacy of a Steel Bridge club at UVA. We worked to recruit new members and establish a club structure to last beyond our time at UVA. Completion of this goal is determined by the active membership at the end of the Spring 2025 semester. Moreover, this goal will be measured based on the involvement of underclassmen in leadership roles at the end of the Spring 2025 Semester.

Design Constraints

Our final design prioritized the strength of the bridge we would be disqualified if the horizontal sway exceeds ¾", and vertical deflection is a significant factor in our team's standing in the competition. Since the total weight of the bridge is also a competition category, we aimed to use the smallest members that kept both the horizontal and vertical displacement under ½" according to the analysis model. We decided to change the truss members to L1-1/2X1-1/2X1/8 and placed three beams for everything chord section instead of two. Since the horizontal sway was significant in the earlier design iterations, we added four sets of cross bracing between the middle chord connections and increased the member size to 2"X1/8" flat bars. We also removed all vertical members since they barely contributed to the stiffness of the bridge.

In the analysis model we assumed simple support conditions, fixed connections between all perpendicular members, and hinged connections between the truss members. There were two possible load cases for the lateral load test as established by the competition rules: 7'0" or 8'6" from one end of the span. Both cases were analyzed and produced similar results. Since the vertical loads are placed on two 3'0" long decking units, it was modeled as four separate 3'0" distributed loads along the north & south top stringers. The total force was 1400 pounds on decking unit #1 and 1100 pounds on decking unit #2, totaling 2500 pounds as the rules dictate. With every iteration of design, we first modeled it in Revit then ran the analysis software to make sure it was stable. After finalizing the structure, we drafted detailed drawings in Revit of the bolted connections. Finally, we created a spreadsheet outlining the amount of each member we need, which was given to Liphart Steel to provide us with a cost estimate.

Conclusion and Discussion

In progressing towards the team's primary goal of fabricating a bridge within the constraints of the ASCE Steel Bridge Competition, the team has completed the design phase of our project and is in the early stages of the fabrication phase. The material for the bridge has been ordered, and we are planning to begin fabricating within the next two weeks. We plan to construct our bridge according to the modeled design. This design has been iteratively analyzed to ensure its strength and stiffness capabilities.

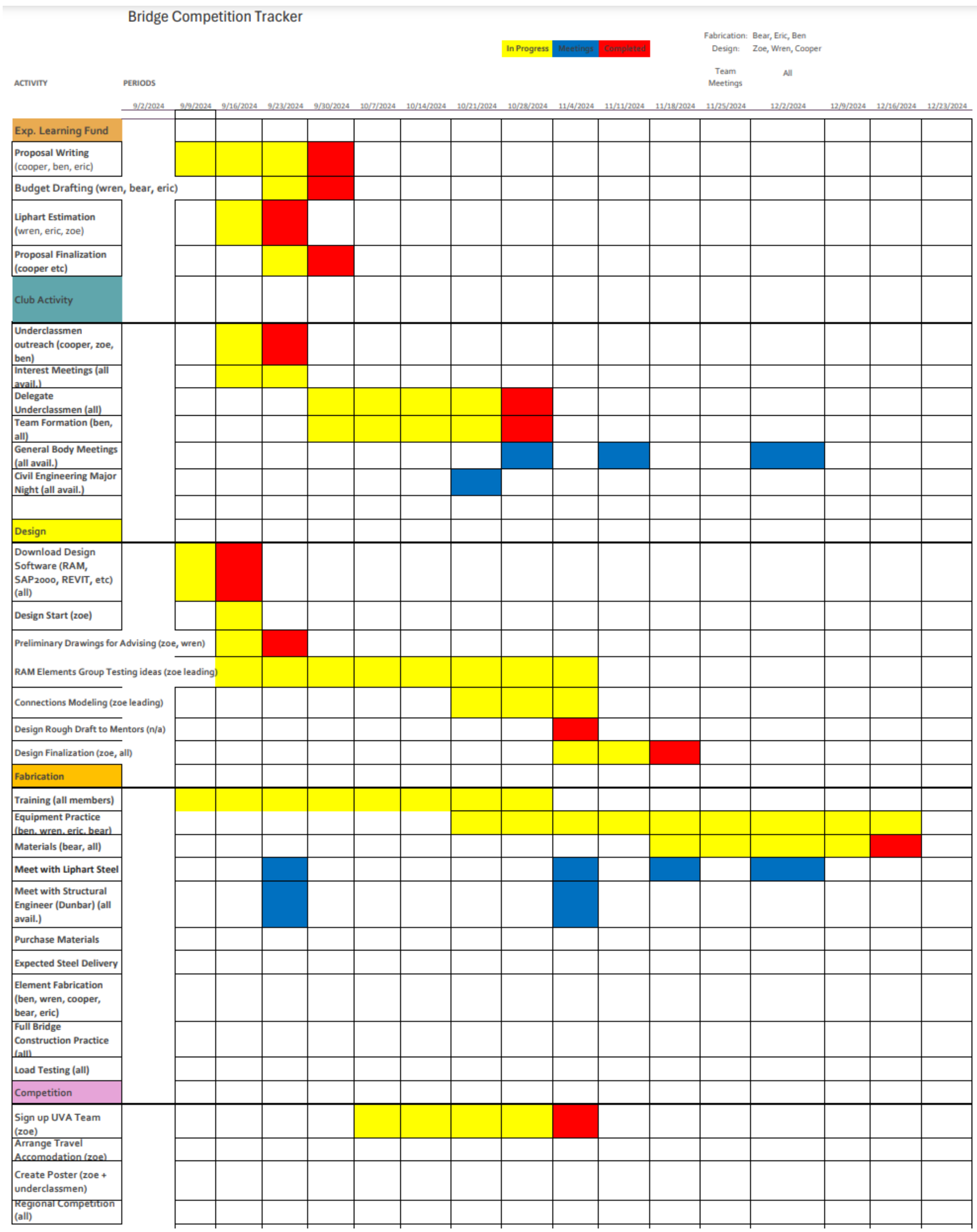
Due to delays with the acquisition of steel, the beginning of the semester focused on working towards achievement of the final goal of leaving a legacy of a sound Steel Bridge Team organization. We have continued to encourage recruitment of new members along with establishing leadership positions for future generations of the team. In combination with fostering a structured group dynamic, the team has been working towards establishing the team as an official CIO according to UVA guidelines. The team has done this by holding modeling and mechanics workshops, encouraging members to obtain safety certification to aid in the fabrication process, and hosting elections to establish future leaders of the organization. The team has been organized into modeling, fabrication, and presentation sub teams. A draft of the club constitution has been created and ratifie. Attendance at club meetings and workshops has been growing, so the team is optimistic that a sound foundation for the Steel Bridge Team will lead to the future development of a thriving organization.

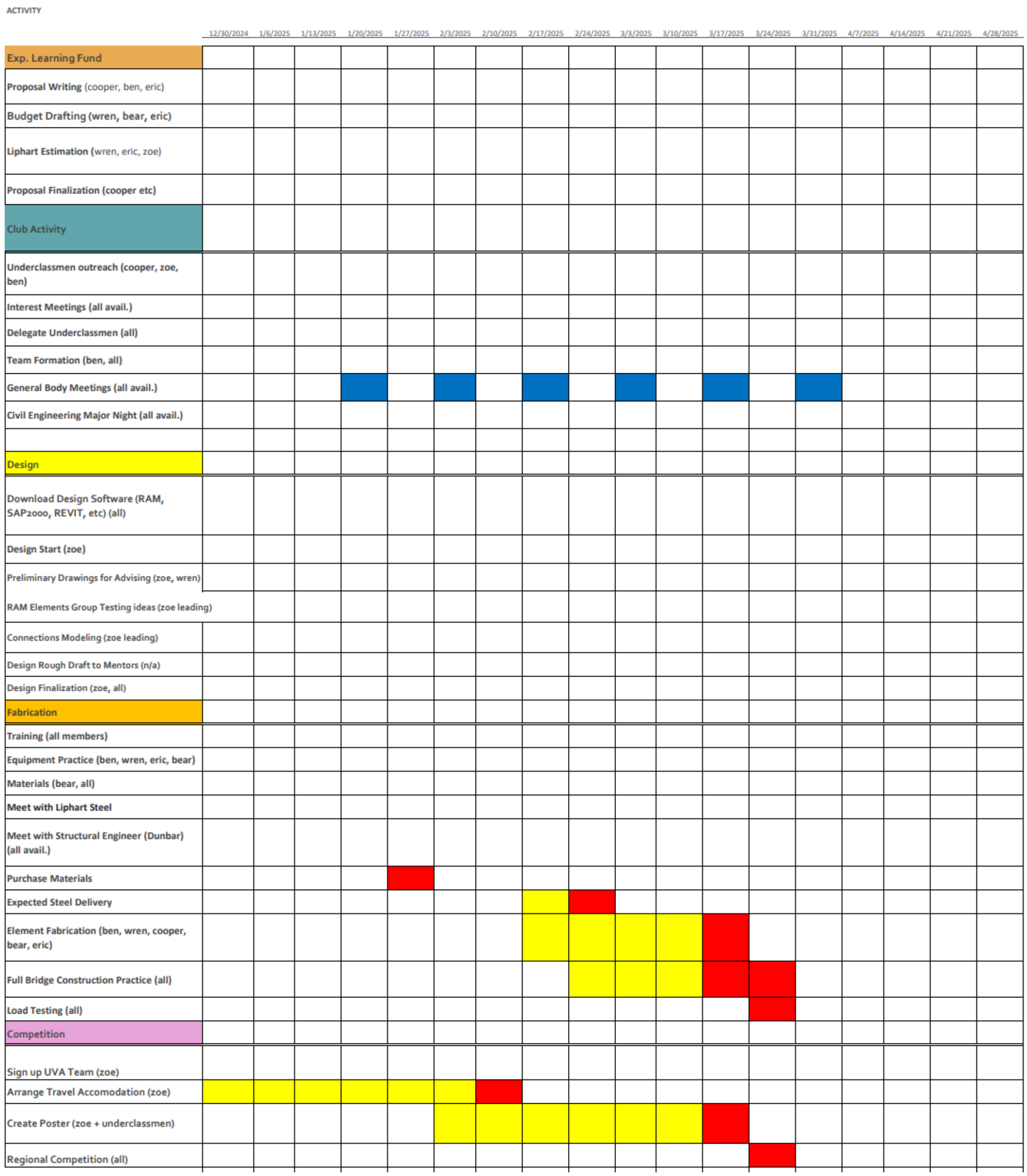
When the steel finally arrived at the end of February, the team completed fabrication and construction practice in the short window of time left before the ASCE/AISC Steel Bridge competition March 28/29th. First, the team completed all safety training and has become acquainted with the equipment to be used for the fabrication of the bridge. After the steel was delivered, the next steps were to measure and count the members to ensure there weren't any errors from the supplier. Next, the team de-rusted the members and removed burrs, established the name and location of the stringer members, and marked all plates, WTs, & angles for bolt holes that were later drilled. The following step was to construct a test section of the bridge without plates or channels welded on, then welded all plates to the WTs and pedestals. Then the team constructed the entire bridge and measured it to make sure it matched the structural drawings. Finally, the channels were welded to the top of the stringers and all members were painted. Before the competition, the bridge was load-tested in the civil engineering lab and deflected approximately 1 inch under a weight of 2500 pounds.

On March 28th and 29th the team traveled and competed in the competition hosted by West Virgina State University in Beckley West Virginia. There, we competed against 7 other Virginia/West Virginia steel bridge teams. This was a significant milestone as it was the first time in 7 years that UVA had competed in the competition. Unfortunately, we were not able to construct the bridge in the required 45-minute period and as a result were disqualified. Although we did not get scored the judges, our results from the horizontal and vertical load tests were competitive with the other teams, giving us confidence in our overall bridge strength. The disqualification was in no way seen as a failure, in fact, competing in the competition alone was our most ambitious goal and getting there was the team's largest success. Now, the 2025 Steel Bridge Team's work is displayed on Engineer's Way representing the hard work of the team and the UVA Civil Engineering department, just as we had hoped.

Appendices

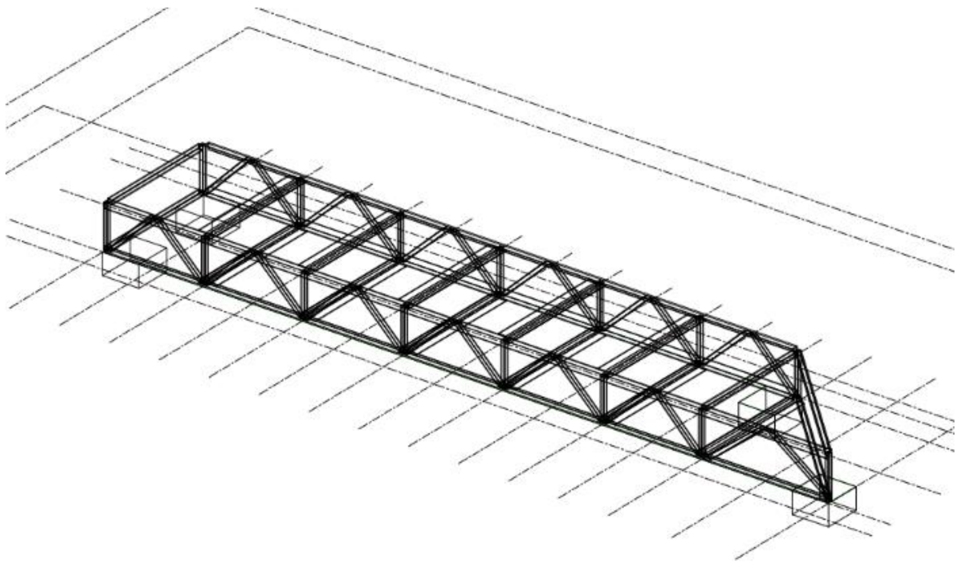
Appendix A – Detailed Schedule



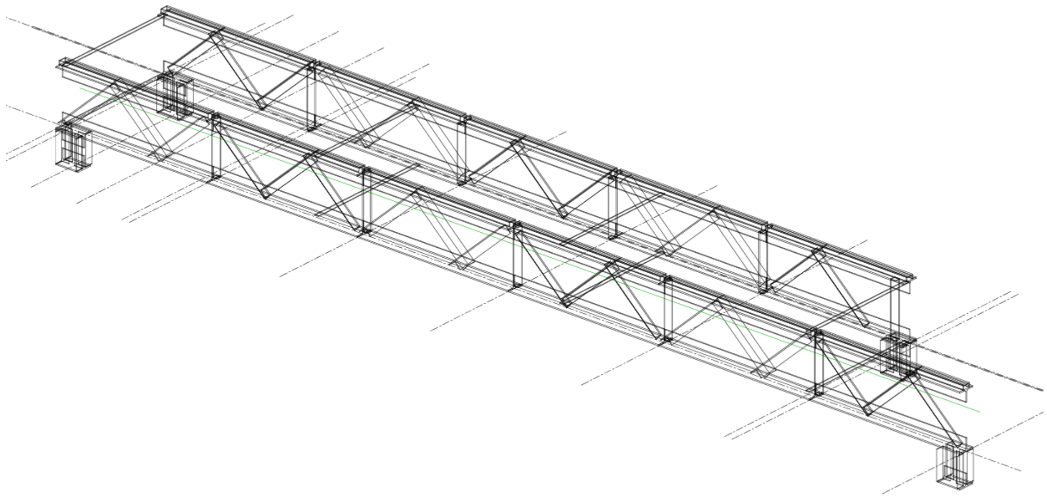


Appendix B – Design Evolution

All iterations of our design followed the dimensional constraints given in the rules and contained top & bottom chords, lateral braces, and truss members along the north and south side. Our first bridge design, pictured below, spanned 16’6” on the north side and 20’0” on the south side. The chords were a combination of 2’9” long L2X2X1/4 members and the truss members were HSS1-1/4X1-1/4X1/8. There were two lateral and two vertical HSS1-1/4X1-1/4X1/8 sections between each angle connection along the span. We decided to abandon this design because it had too much steel, which made it unnecessarily heavy and would take too long to construct.



Our second set of structural plans used a 3’4” long WT3X6 members for chords. We also added a 2” wide channel along the top chord so it can follow the stringer template provided at the competition. The truss members were changed to L2X2X1/8, and the lateral braces were changed to 1”X1/8” flat bars. Instead of adding lateral members at every WT connection, we placed two horizontal members at four locations equally spaced along the span. We ultimately had to update this design because the analysis model failed the steel design code checks and deflected more than the competition rules allowed.



Details for our final bridge design are provided in the main report. We ultimately chose members that provided adequate strength without being too heavy or too difficult to construct.

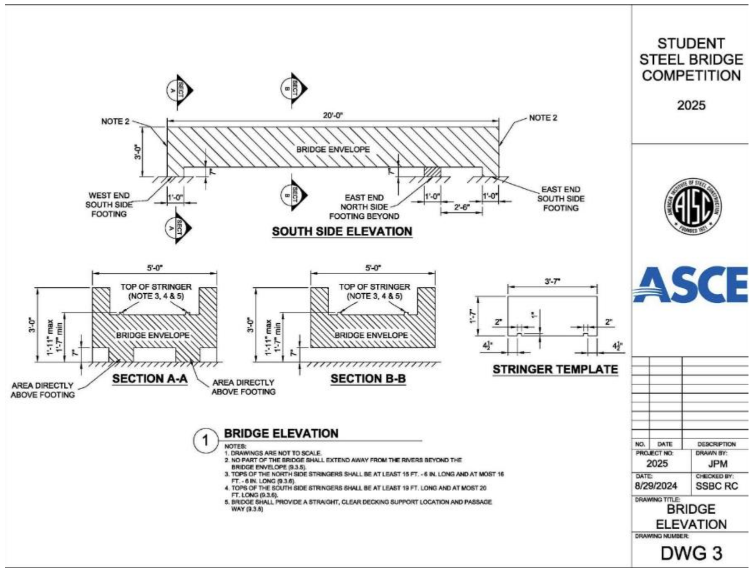
Appendix C – Engineering Standards

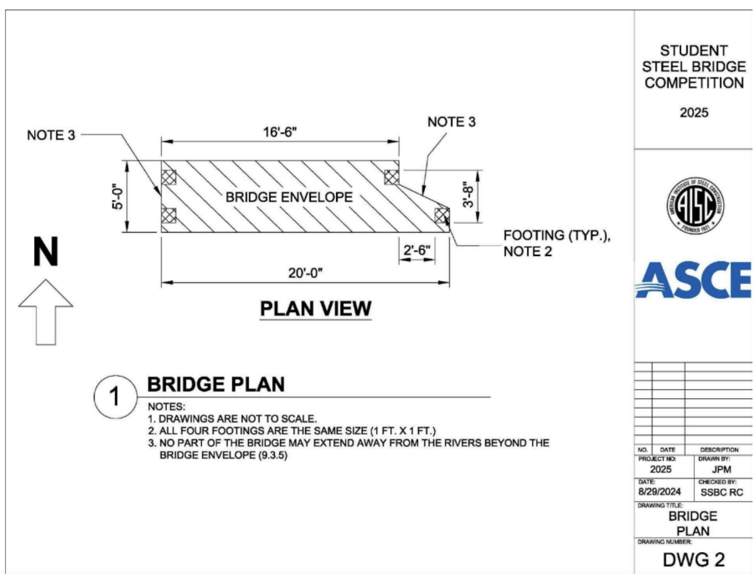
The ASCE & AISC Student Steel Bridge Competition (SSBC) requires specific bridge dimensions and constraints outlined in their 2025 Official Student Steel Bridge Competition Rules. Section 9 of this specification states that bridge must comply with the following dimensions, additionally outlined by images taken from the SSBC Rules.

Dimensions (Section 9 of SSBC Rules) -

- Maximum height – 3'0" above ground/river
- Height of stringer – 1'7" to 1'11" (measured at T/STL)
- Width – 3'6" to 5'0"
- Minimum vertical clearance – 0'7" (i.e. minimum footing height)
- Span length of north side stringer – 15'6" to 16'6"
- Span length of south side stringer – 19'0" to 20'0"
- Stringer members must be straight across and fully connected
- Maximum horizontal separation between stringer members – 0' ¼"

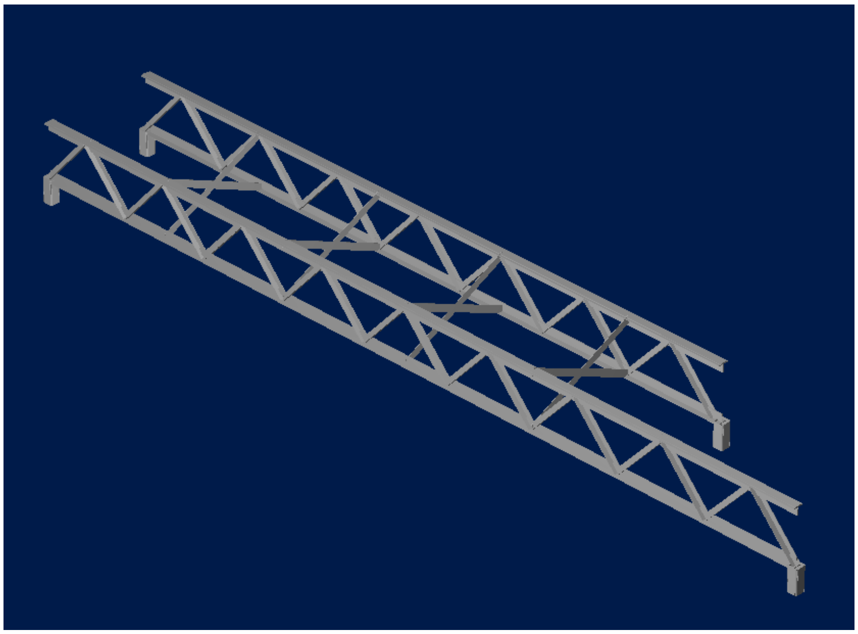
- Maximum elevation difference along stringer – 0' 1/8"
- Each member fits into 3'6" X 0'6" X 0'4" box
- No cables



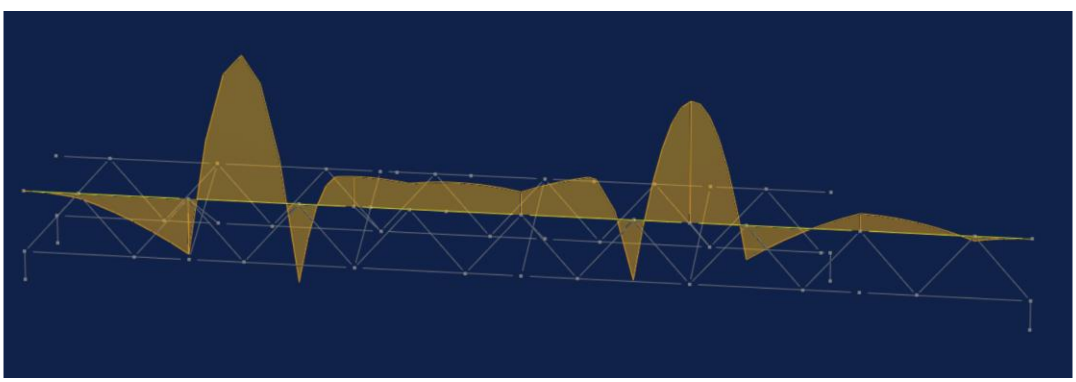


Additionally, the rules state that the bridge must be built entirely built from steel, and it must be stable, or else the bridge is disqualified from competition. Our bridge is demonstrated to comply with these guidelines, as illustrated by our final design drawings shown in the report and in Appendix B & D.

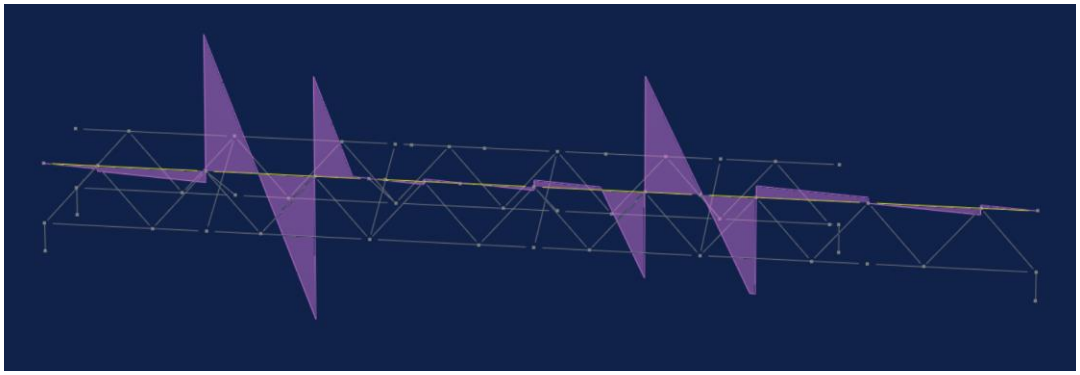
The bridge was designed using typical AISC-specified A992 and A36 steel, using load combinations and LRFD methodology outlined in Specification B of AISC 360-16 Specification for Structural Steel Buildings. This compliance is reflected in our structural analysis diagrams created from RAM Elements:



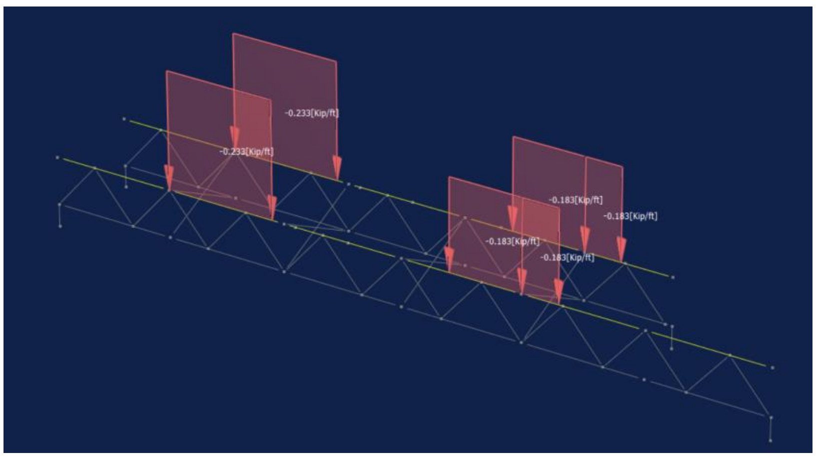
Rendered Model



Moment Diagram



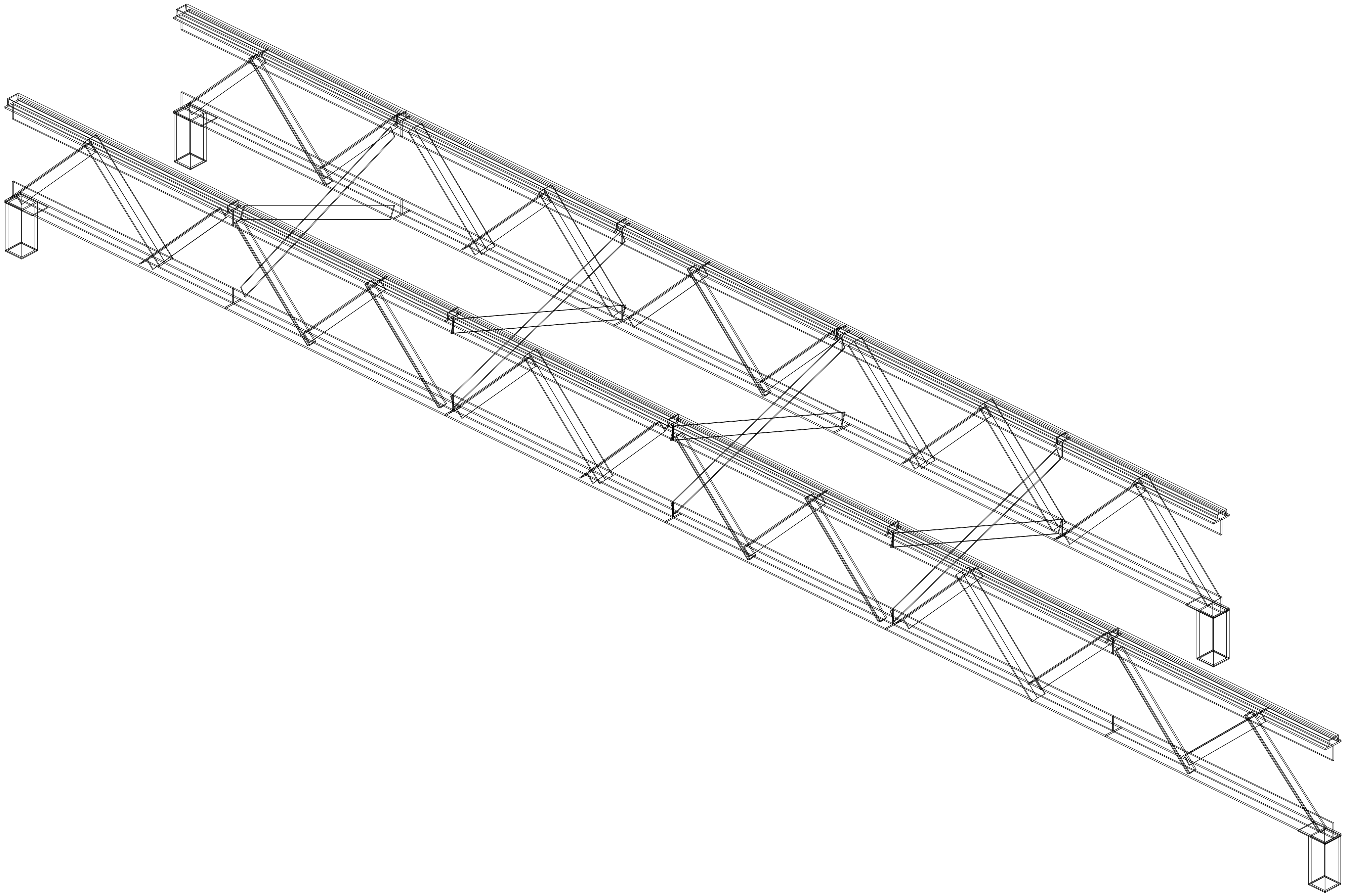
Shear Diagram



Load Diagram

Appendix D – Technical Deliverables

Attached with this report is a copy of structural drawings drafted in Revit, the displacement results from the analysis software, and the steel code checks for each member.



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STEEL BRIDGE COMPETITION

3D ISOMETRIC

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Drawn By	Author
Checked By	Checker

S1

Scale

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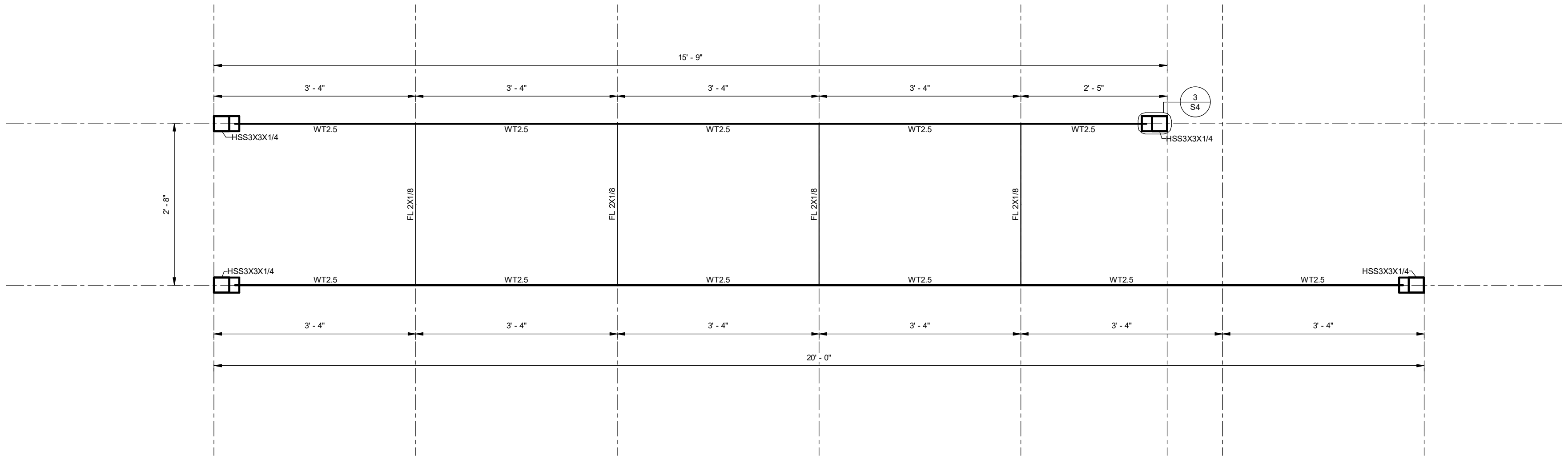
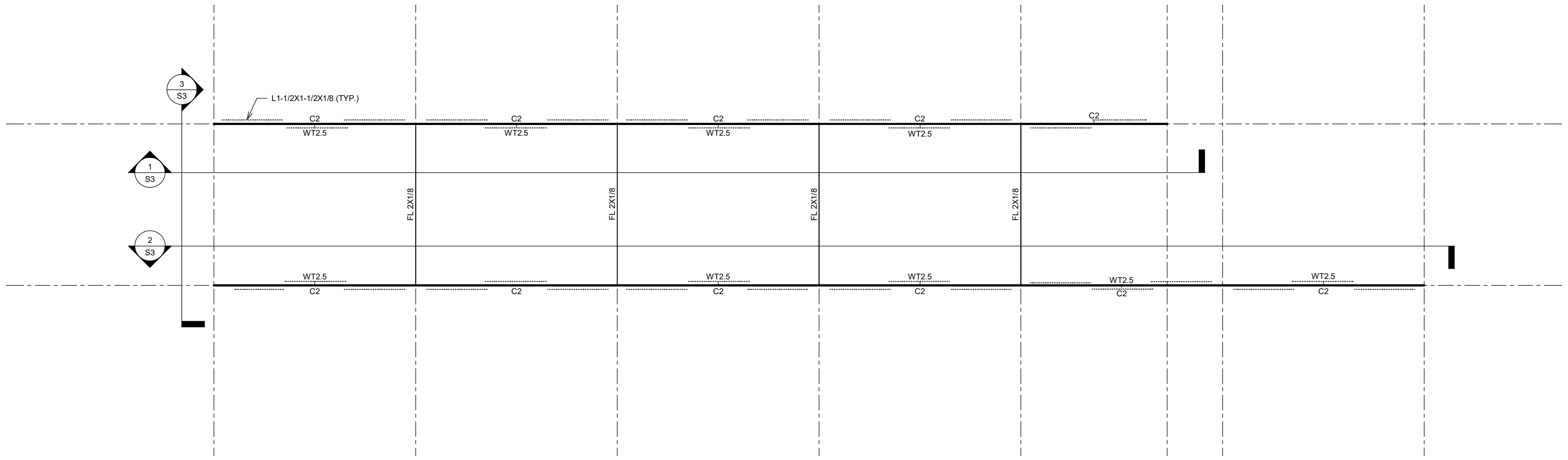


1 T/PEDESTAL
1" = 1'-0"



2 T/STL
1" = 1'-0"

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STEEL BRIDGE COMPETITION

PLAN VIEWS

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Scale 1" = 1'-0"

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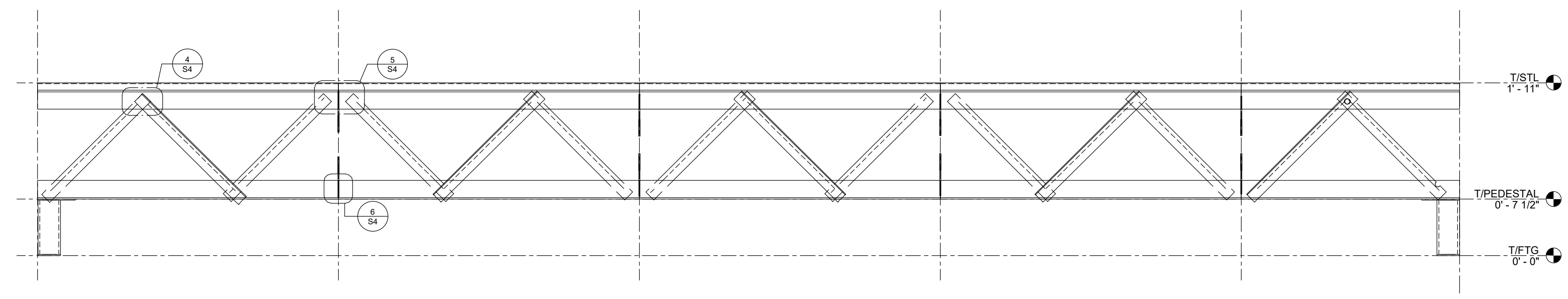
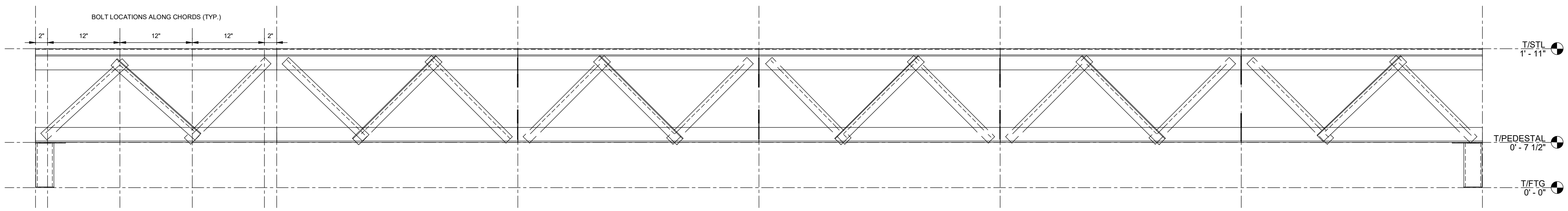
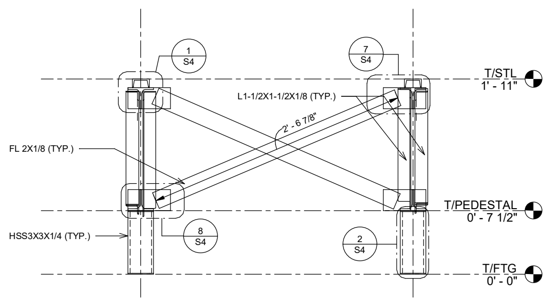


1 Section 1
1 1/2" = 1'-0"



2 Section 2
1 1/2" = 1'-0"



3 Section 3
1 1/2" = 1'-0"

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STEEL BRIDGE COMPETITION

SECTIONS

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S3

Scale	1 1/2" = 1'-0"

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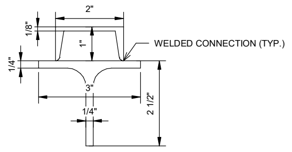
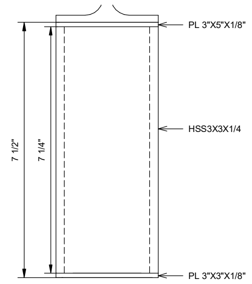
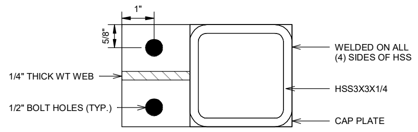


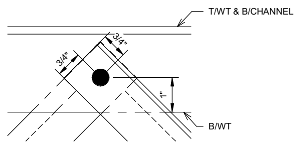
1 TOP CHORD SECTION
6" = 1'-0"



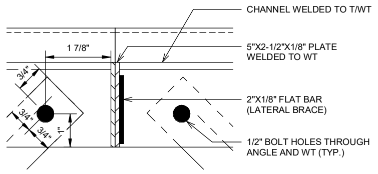
2 PEDESTAL
6" = 1'-0"



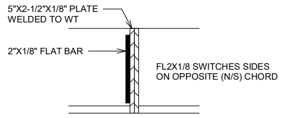
3 PEDESTAL - TOP VIEW
6" = 1'-0"



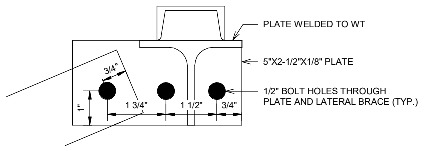
4 ANGLE-WT CONNECTION
6" = 1'-0"



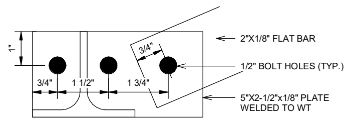
5 TOP CHORD CONNECTION
6" = 1'-0"



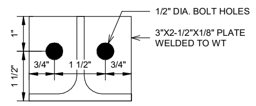
6 BOTTOM CHORD CONNECTION
6" = 1'-0"



7 TOP CHORD PLATE CONNECTION
6" = 1'-0"



8 BOTTOM CHORD PLATE CONNECTION
6" = 1'-0"



9 CONNECTION W/O LATERAL BRACE
6" = 1'-0"

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UVA

STEEL BRIDGE COMPETITION

DETAILS

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S4

Scale	6" = 1'-0"

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Lateral Load Test Analysis Results (LC #1)

Displacement of Top Chord Connection Points (in)

Node	ΔX	ΔY	ΔZ
25	0.00086	-0.00015	0.28443
26	0.00086	-0.00188	0.29896
27	0.00076	-0.00547	0.32803
28	0.00056	-0.00835	0.35486
29	0.00043	-0.00943	0.36395
30	0.0003	-0.0102	0.36765
31	0.00001	-0.01086	0.35027
32	-0.00028	-0.01027	0.31029
33	-0.00041	-0.00966	0.28696
34	-0.00054	-0.00839	0.26338
35	-0.00074	-0.00539	0.21623
36	-0.00083	-0.00184	0.1691
37	-0.00083	-0.00014	0.14553
38	0.00026	-0.00017	0.29915
39	0.00026	-0.00119	0.31068
40	0.00018	-0.00347	0.33391
41	0.00001	-0.00526	0.35509
42	-0.00011	-0.00569	0.3612
43	-0.00023	-0.00618	0.36212
44	-0.00048	-0.00556	0.34755
45	-0.00067	-0.00371	0.31358
46	-0.00072	-0.00265	0.29305
47	-0.00077	-0.00132	0.27236
48	-0.00077	0.00005	0.2481
52	-0.00057	-0.00469	0.33408
57	0.00021	-0.01058	0.36586
58	-0.00031	-0.0067	0.35979

Vertical Load Test Analysis Results (LC #1)

Displacement of Top Chord Connection Points (in)

Node	ΔX	ΔY	ΔZ
25	0.00735	-0.00121	0.00358
26	0.00735	-0.01313	0.00562
27	0.00657	-0.039	0.00972
28	0.005	-0.05848	0.01383
29	0.00405	-0.06341	0.01589
30	0.0031	-0.06848	0.01795
31	0.00112	-0.07054	0.02173
32	-0.00068	-0.0625	0.02469
33	-0.00136	-0.05585	0.026
34	-0.00204	-0.0482	0.02729
35	-0.00294	-0.02972	0.02987
36	-0.00329	-0.00975	0.03244
37	-0.00329	0.00018	0.03373
38	0.0027	-0.00129	0.0044
39	0.0027	-0.00853	0.00649
40	0.00202	-0.02513	0.01067
41	0.00071	-0.03577	0.01481
42	-0.00005	-0.03669	0.01677
43	-0.00081	-0.03811	0.0186
44	-0.00227	-0.03423	0.02194
45	-0.0034	-0.02248	0.02502
46	-0.00368	-0.01497	0.02652
47	-0.00395	-0.00756	0.02802
48	-0.00395	0.00085	0.02977
52	-0.00278	-0.03024	0.02334
57	0.00246	-0.07134	0.01925
58	-0.00128	-0.03883	0.01972

Steel Code Check

Load conditions to be included in design :
LC1=1.4VERT

Section	Member	Ctrl Eq.	Ratio	Status
FL 2X1/8	106	LC1 at 50.00%	0.01	OK
	107	LC1 at 100.00%	0.05	With warnings
	112	LC1 at 50.00%	0.01	OK
	113	LC1 at 0.00%	0.02	With warnings
	124	LC1 at 50.00%	0.01	OK
	125	LC1 at 50.00%	0.02	With warnings
	126	LC1 at 100.00%	0.02	With warnings
	127	LC1 at 50.00%	0.01	OK
HSS_SQR 3X3X1_4	108	LC1 at 0.00%	0.06	OK
	109	LC1 at 0.00%	0.07	OK
	110	LC1 at 0.00%	0.07	OK
	111	LC1 at 0.00%	0.05	OK
L 1-1/2X1-1/2X1/8	73	LC1 at 50.00%	0.19	OK
	74	LC1 at 50.00%	0.12	OK
	75	LC1 at 50.00%	0.24	OK
	76	LC1 at 50.00%	0.09	OK
	77	LC1 at 50.00%	0.13	OK
	78	LC1 at 50.00%	0.02	OK
	79	LC1 at 50.00%	0.03	OK
	80	LC1 at 50.00%	0.01	OK
	81	LC1 at 50.00%	0.01	OK
	82	LC1 at 50.00%	0.1	OK
	83	LC1 at 50.00%	0.06	OK

	84	LC1 at 50.00%	0.11	OK
	85	LC1 at 50.00%	0.07	OK
	86	LC1 at 50.00%	0.12	OK
	87	LC1 at 50.00%	0.08	OK
	88	LC1 at 50.00%	0.14	OK
	89	LC1 at 50.00%	0.05	OK
	90	LC1 at 50.00%	0.09	OK
	91	LC1 at 50.00%	0.17	OK
	92	LC1 at 50.00%	0.1	OK
	93	LC1 at 50.00%	0.2	OK
	94	LC1 at 50.00%	0.07	OK
	95	LC1 at 50.00%	0.1	OK
	96	LC1 at 50.00%	0	OK
	97	LC1 at 50.00%	0	OK
	98	LC1 at 50.00%	0.03	OK
	99	LC1 at 50.00%	0.02	OK
	100	LC1 at 50.00%	0.13	OK
	101	LC1 at 50.00%	0.09	OK
	102	LC1 at 50.00%	0.15	OK
	103	LC1 at 50.00%	0.08	OK
	104	LC1 at 50.00%	0.14	OK
WT 2.5X5	11	LC1 at 0.00%	0.16	OK
	13	LC1 at 0.00%	0.06	OK
	15	LC1 at 0.00%	0.06	OK
	17	LC1 at 0.00%	0.05	OK
	18	LC1 at 100.00%	0.16	OK
	25	LC1 at 0.00%	0.21	OK
	26	LC1 at 33.33%	0.07	OK
	27	LC1 at 66.67%	0.08	OK
	28	LC1 at 0.00%	0.08	OK
	29	LC1 at 100.00%	0.04	OK
	30	LC1 at 100.00%	0.21	OK

WT 2.5X5 & PL2X3/16	1	LC1 at 100.00%	0.04	OK
	3	LC1 at 33.33%	0.1	OK
	5	LC1 at 0.00%	0.07	OK
	7	LC1 at 0.00%	0.05	OK
	9	LC1 at 0.00%	0.02	OK
	19	LC1 at 100.00%	0.04	OK
	20	LC1 at 33.33%	0.1	OK
	21	LC1 at 55.00%	0.1	OK
	22	LC1 at 0.00%	0.09	OK
	23	LC1 at 0.00%	0.07	OK
	24	LC1 at 0.00%	0.02	OK