
2016 ASCE STEEL BRIDGE



CENE 486C – FINAL PRESENTATION

Kaitlin Vandaveer – Project Manager/Scheduling Engineer

Logan Couch – RISA Design Engineer/Materials Engineer

Brian Jouflas – AutoCAD Design Engineer

Matthew Rodgers – Conference Captain

PROJECT BACKGROUND

- Design, fabricate, and construct a 1:10 scale model of bridge
- Compete at 2016 ASCE Pacific Southwest Conference
- Competition Rule Constraints
 - Bridge must fit within envelope
 - Maximum construction time of 45 minutes
 - Lateral and vertical loading tests

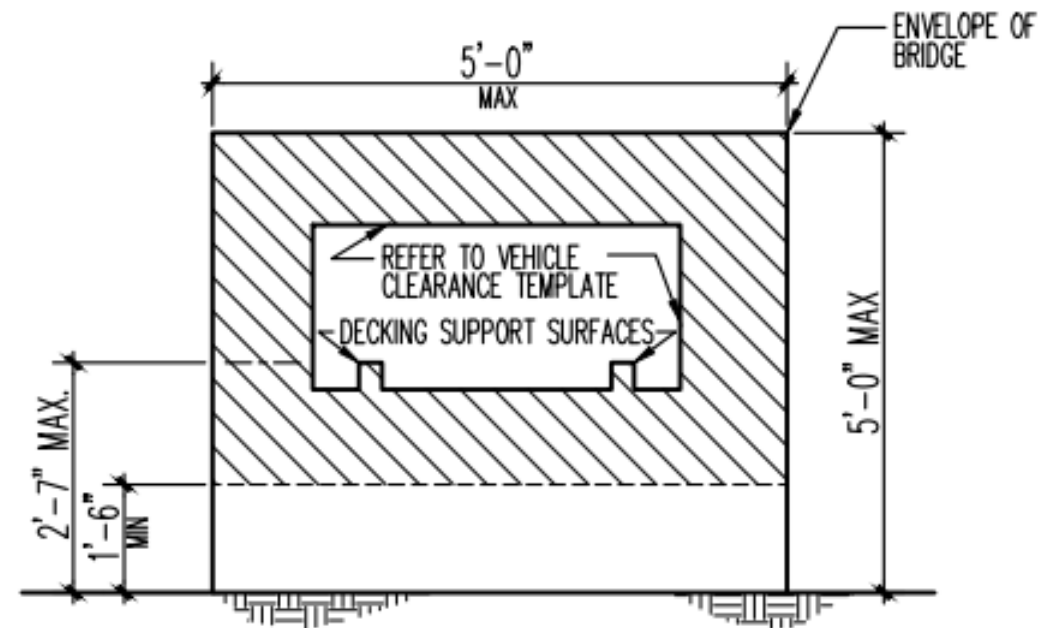


Figure 1: Bridge Envelope

PROJECT CLIENT, TECHNICAL ADVISOR, AND STAKEHOLDERS

■ Client:

- Mark Lamer, P.E.



■ Stakeholders

- Northern Arizona University
- NAU ASCE Student Chapter
- NAU CECMEE Department

■ Technical Advisor:

- Thomas Nelson, P.E.



DESIGN OPTIONS

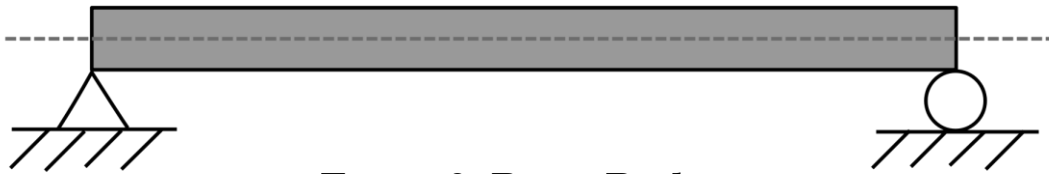


Figure 2: Beam Bridge

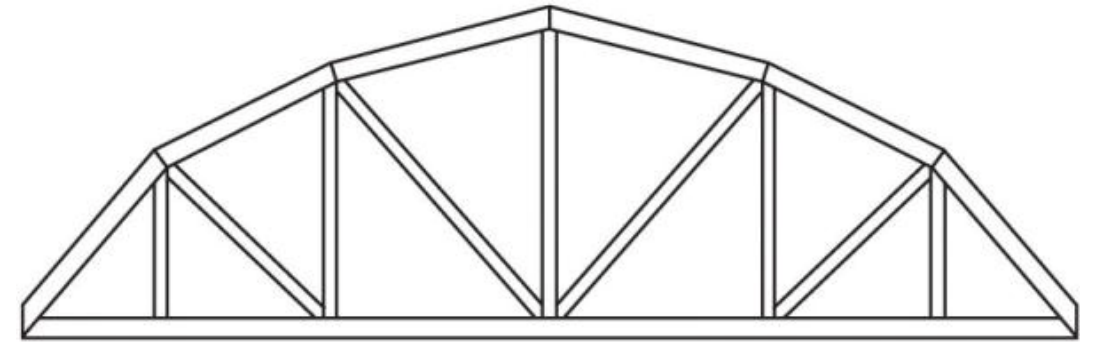


Figure 3: Bowstring Truss

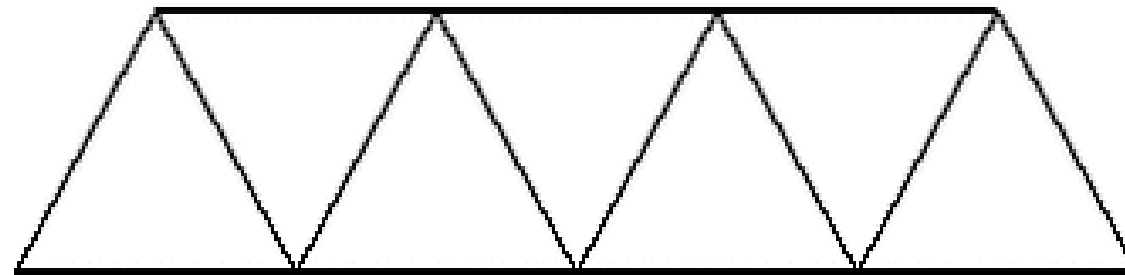


Figure 4: Warren Truss

DESIGN OPTIONS

Decision Matrix

Scale: 1 = worst score, 5 = best score

	Beam	Bowstring	Warren
Constructability (10%)	5	2	3
Usability (10%)	3	3	3
Stiffness (20%)	2	5	4
Construction Speed (15%)	5	2	2
Efficiency (20%)	2	3	5
Economy (20%)	4	2	2
Aesthetics (5%)	3	5	3
TOTAL WEIGHTED SCORE	3.3	3.05	3.25

ANALYSIS – OVERALL DESIGN

■ RISA 3D Analysis

- Applied all 6 load combinations
- Boundary conditions and end constraints

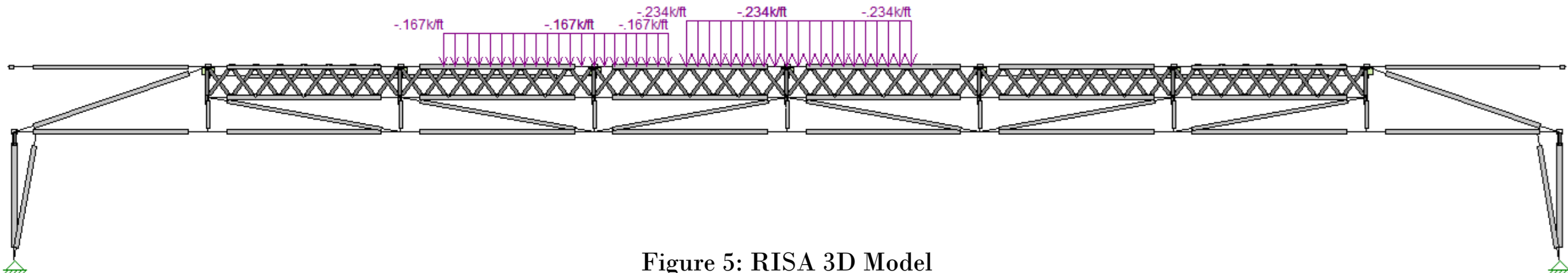


Figure 5: RISA 3D Model

ANALYSIS – OVERALL DESIGN

■ Lateral Deflection

- Initial RISA 3D Calculated Deflection = 1.5 in
- Final RISA 3D Calculated Deflection = 0.2 in

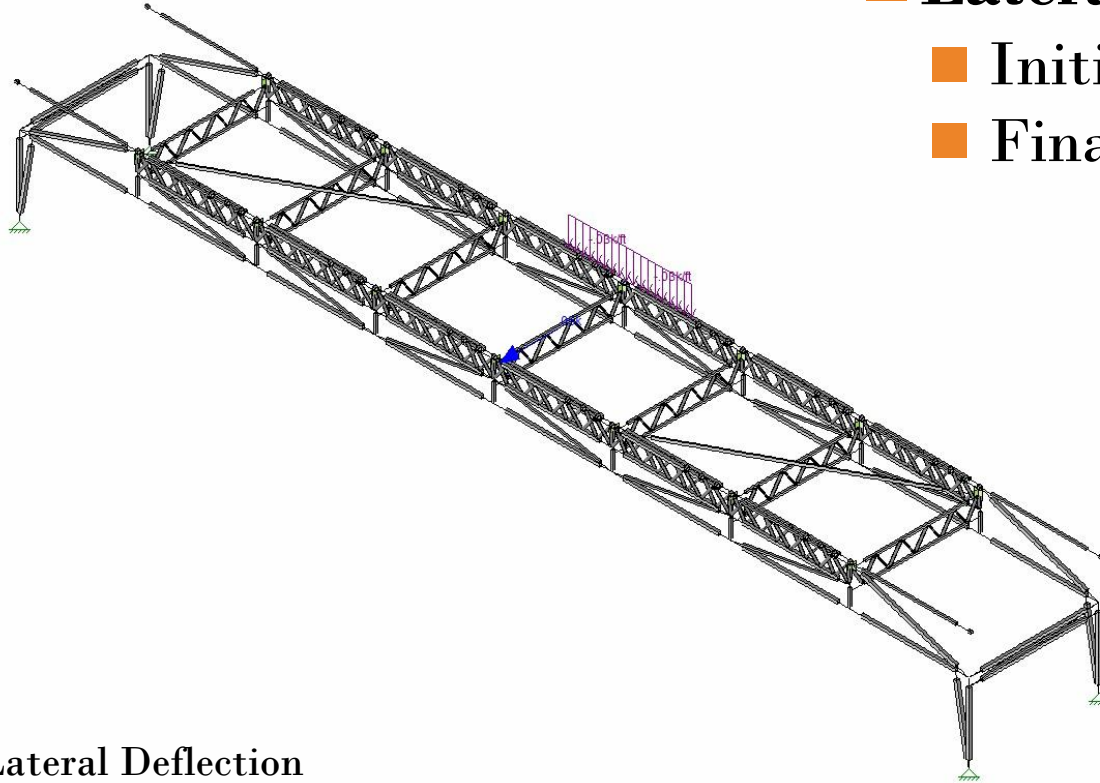


Figure 6: Lateral Deflection

*Deflection diagram exaggerated by a factor of 100

ANALYSIS – OVERALL DESIGN

■ Vertical Deflection

- Initial RISA 3D Calculated Deflection = 2.8 in
- Final RISA 3D Calculated Deflection = 0.75 in

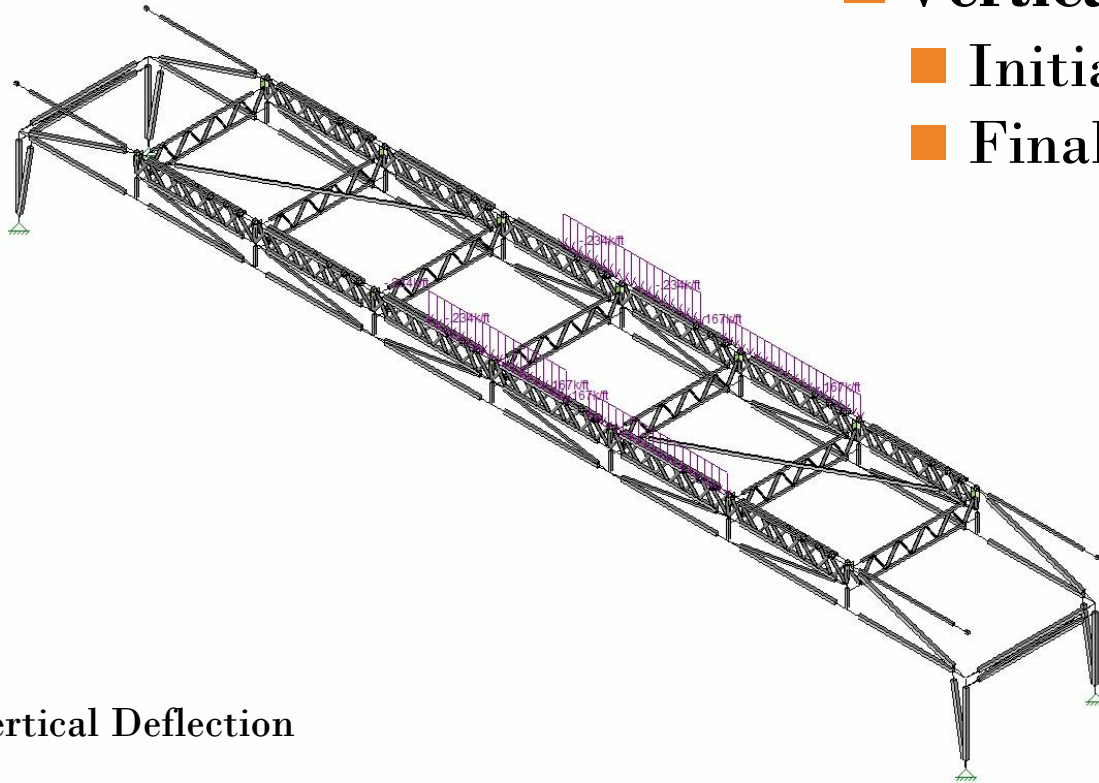


Figure 7: Vertical Deflection

*Deflection diagram exaggerated by a factor of 100

ANALYSIS – MEMBER DESIGN

■ Member Section Properties

- Analyzed forces in each member
- Three different section sets:
 - 11ga $\frac{3}{4}$ " HSS tube
 - 16ga $\frac{1}{2}$ " HSS tube
 - $\frac{1}{4}$ " solid round rod

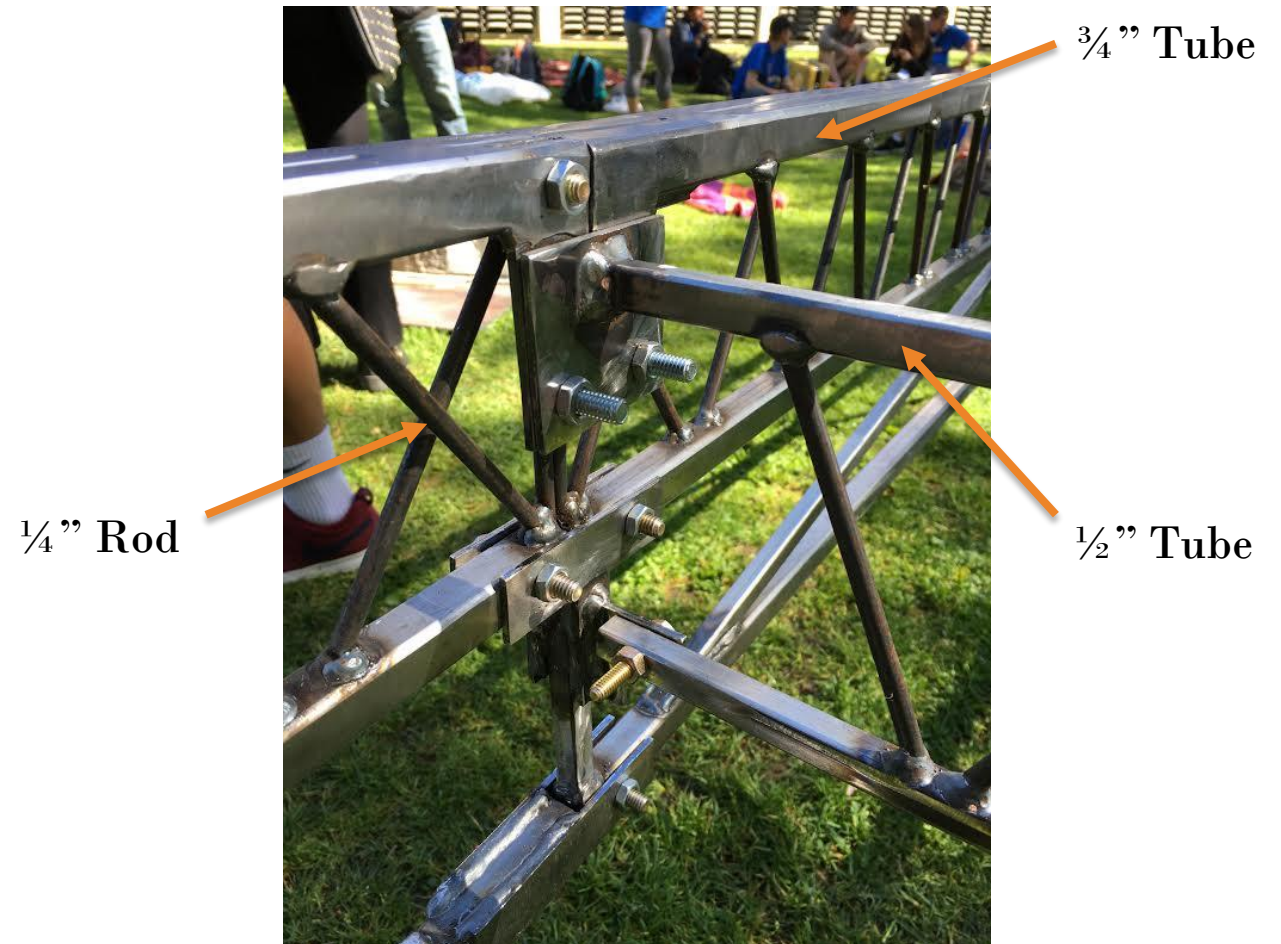


Figure 8: Bridge Material

ANALYSIS – CONNECTION DESIGN

Connection Calculations

- Tension
- Yielding
- Rupture
- Block Shear
- Plate Flexure
- Bearing Strength

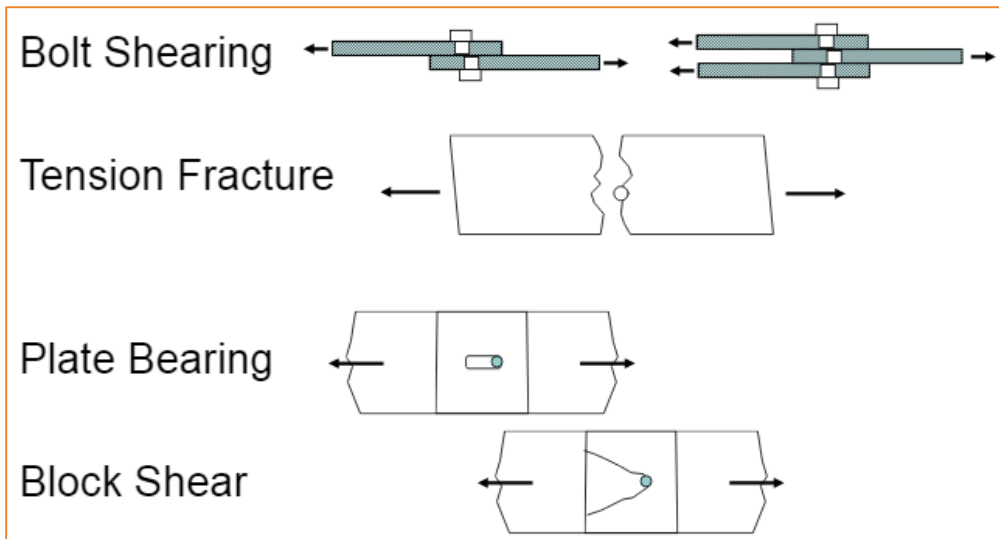


Figure 9: Connection Failures

Block Shear Strength

10 ga x 1" Plate			
F_y	=	33.0	ksi
A_{nv}	=	0.269	in ²
A_{nt}	=	0.135	in ²
Edge Dist.	=	1	in
U_{bs}	=	0.5	
R_n	=	7.55	kips

Bearing Strength at Bolt Holes

F_u	=	50.0	ksi
t	=	0.135	in
L_c	=	1	in
R_n	=	8.07	kips

Tension & Shear of Bolts/Threads

$F_y (V)$	=	91.0	ksi
$F_y (T)$	=	150.0	ksi
A_w	=	0.049	in ²
V_n	=	4.46	kips
T_n	=	7.36	kips

Yellow = Input

Green = Results

BRIDGE DESIGN PLANS

Overall Dimensions

Material List

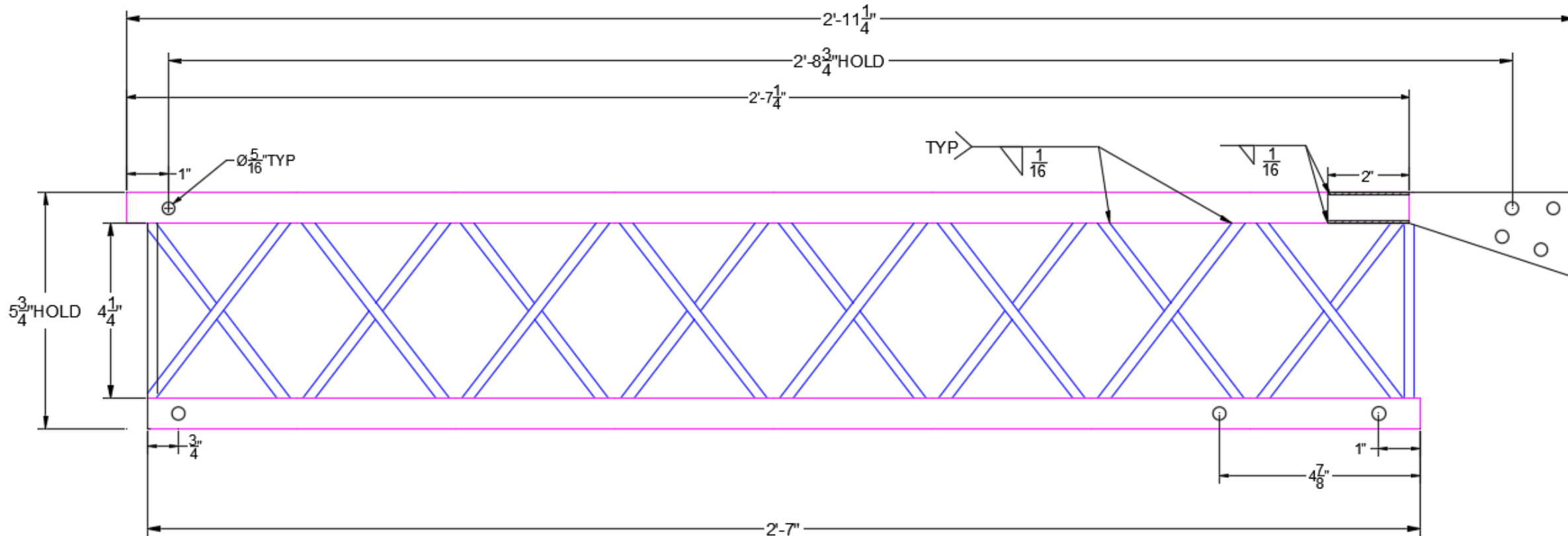


Figure 10: Truss Member Drawing

FABRICATION

- Material Preparation
- Cutting Members and Plates
- Drilling
- Welding

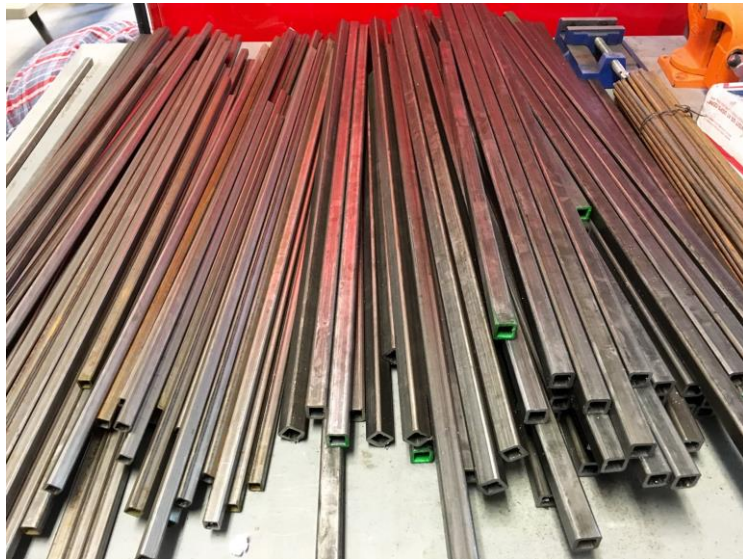


Figure 11: Bridge Material

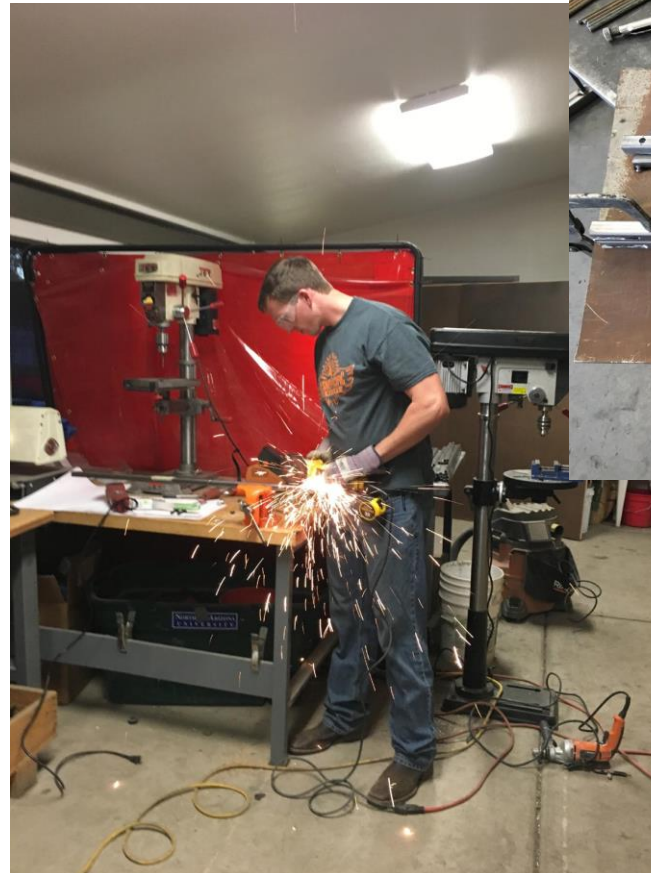


Figure 12: Fabrication Work

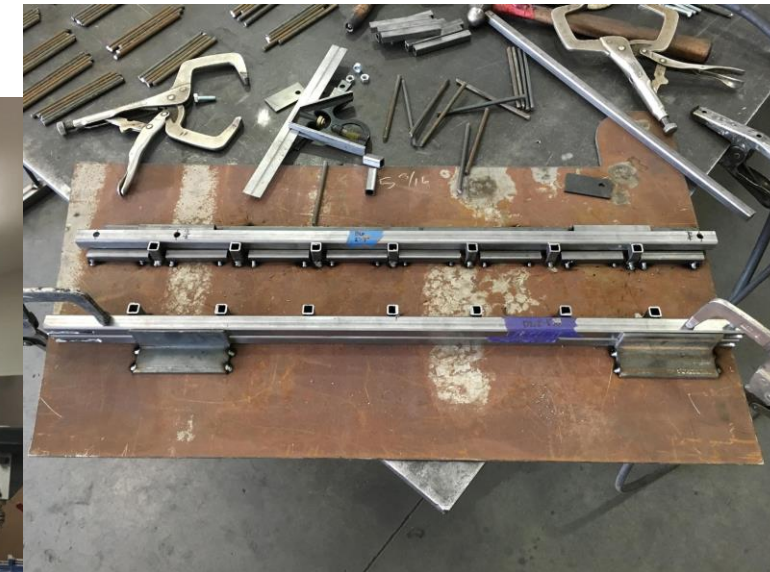


Figure 13: Welding Jig

CONSTRUCTION PRACTICE

- 11 Total Practices
- 1st Practice: 1 hour build time
- 3rd Practice: 32 minute build time
- Best Practice: 26 minute build time

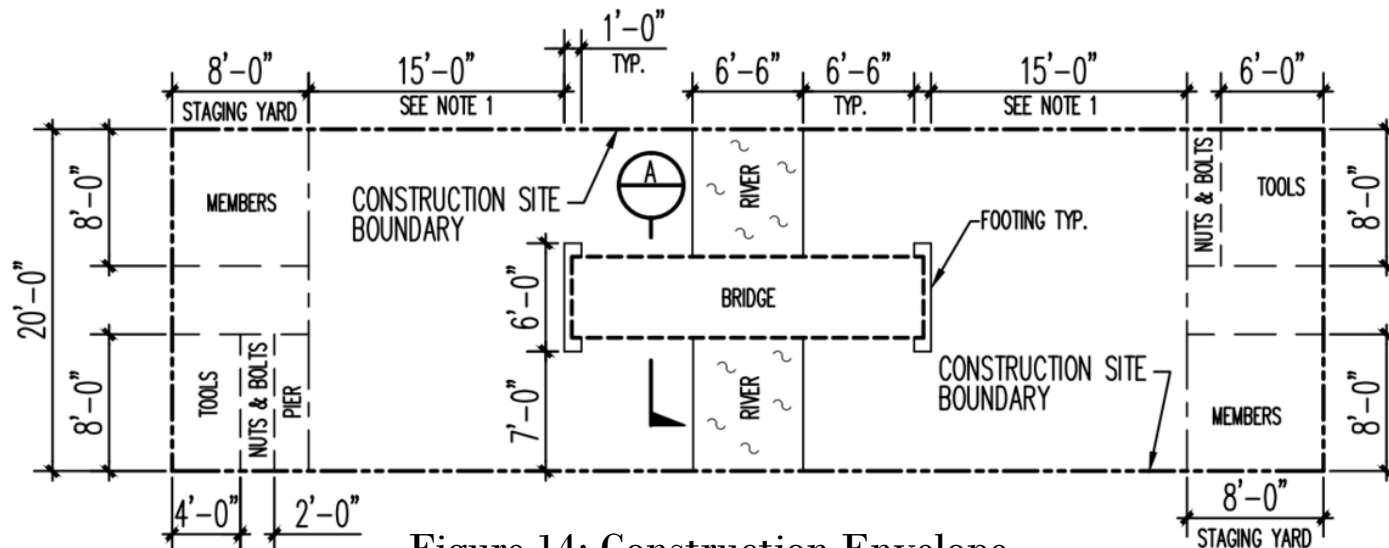


Figure 14: Construction Envelope

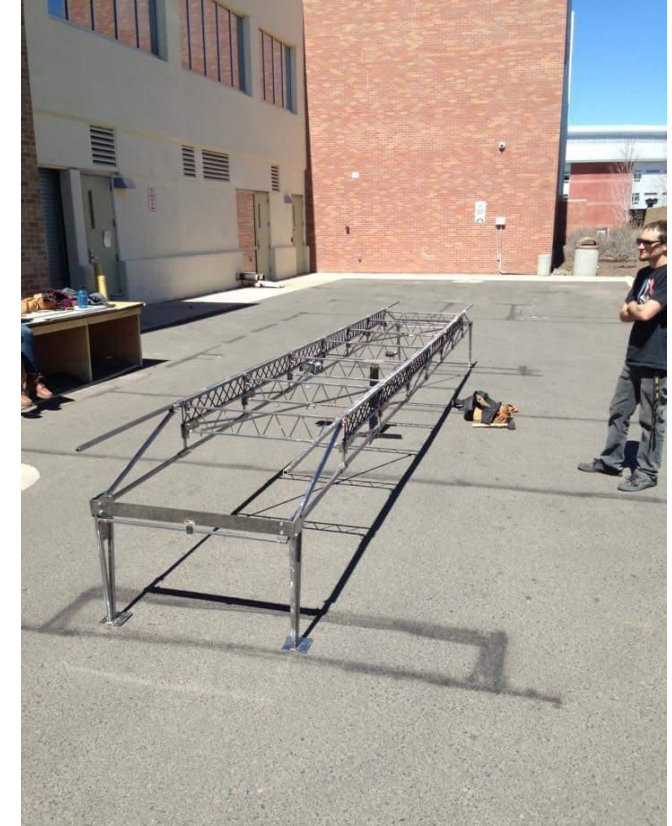


Figure 15: Construction Practice

PACIFIC SOUTHWEST CONFERENCE

■ Display Day



Figure 16: Bridge Display

■ Steel Bridge Competition

- Timed construction
- Loading test



Figure 17: Timed Construction



Figure 18: Vertical Load Test

PACIFIC SOUTHWEST CONFERENCE

■ Results

- Stiffness: 2.1in vertical deflection, 0.25in lateral deflection, and 4.97in aggregate deflection (Estimated vertical deflection = 0.75in; Estimated lateral deflection = 0.2in)
- Construction Speed: 25min 16s
- Weight: 273lbs (Estimated weight = 250lbs)
- Economy: \$15,610,000
- Efficiency: \$27,695,000
- Display: 3rd Place
- Overall: 6th place with \$43,305,000



Figure 19: 3rd Place for Display

SCHEDULE UPDATE

Task	Expected Deadline Date	Actual Date of Completion
1.0 Background Research	September 25, 2016	September 25, 2016
2.0 Preliminary Design	October 8, 2016	October 8, 2016
3.0 Final Design		
3.1 RISA 3D Design	November 30, 2016	December 9, 2016
3.2 Member Design Details	November 30, 2016	December 9, 2016
3.3 Connection Design	November 30, 2016	December 14, 2016
4.0 Bridge Design Plans	December 14, 2016	January 20, 2016
5.0 Fabrication		
5.1 Preparation	January 19, 2016	January 23, 2016
5.2 Cutting	February 12, 2016	February 27, 2016
5.3 Drilling	February 24, 2016	February 27, 2016
5.4 Welding	March 10, 2016	March 22, 2016
6.0 Construction	March 29, 2016	March 29, 2016
7.0 Pacific Southwest Conference	March 31, 2016 - April 2, 2016	March 31, 2016 - April 2, 2016
8.0 CENE 486c Deliverables		
8.1 50% Design Report	March 11, 2016	March 11, 2016
8.2 UGRADS Presentation	April 29, 2016	April 29, 2016
8.2 100% Design Report	May 12, 2016	May 12, 2016
8.3 Website	May 12, 2016	May 12, 2016

Orange = Behind Schedule

COST OF SERVICES

Total Cost of Engineering Services				
Service	Estimated	Actual	Estimated Cost	Actual Cost
1.0 Personnel	845 Hours	1445 Hours	\$83,200	\$111,215
2.0 Pacific Southwest Conference				
2.1 Travel Mileage	1630 Miles at \$0.45/mile	1055 at \$0.54/mile	\$735	\$570
2.2 Hotel (2 Rooms)	4 Nights at \$125/night	4 Nights at \$150/night	\$900	\$1,200
2.3 Van Rental	5 Days at \$50/day	5 Days at \$55/day	\$250	\$275
3.0 Subcontractors				
3.1 Water Jet Plates	Dollars		\$200	\$50
3.2 Welding	Dollars		\$2,000	\$1,280
4.0 Materials	Dollars		\$1,100	\$1,160
Total Cost			\$88,385	\$115,750

CONCLUSION

■ Impacts

- Institutional background for future teams
- RISA 3D Model
- Connection Design Spreadsheet
- Quality Design Plans

■ Recommendations

- More analysis for connection design
- Use other software such as ANSYS or SAP 2000
- Stay on schedule – have design complete before winter break



THANK YOU