# ASCE/AISC
# 2015 STEEL BRIDGE
## TRUSSANASAUROUS REX

CENE486 – FINAL PRESENTATION

WENDY CLARK, NOEL CRUZ, SARAH HIGGINS, LAUREN STADELMEIER

# PROJECT TEAM

- Noel Cruz – Project Manager/Materials Engineer
- Lauren Stadelmeier – Conference Captain/Safety Engineer
- Wendy Clark – Scheduling Engineer
- Sarah Higgins – Design Engineer

# PROJECT BACKGROUND

- "A comprehensive, student-driven project experience from conception and design through fabrication, erection, and testing"
- Sponsored by:
  - American Institute of Steel Construction (AISC)
  - American Society of Civil Engineers (ASCE)
- Pacific Southwest ASCE Conference (PSWC)
- Model built for the country of Kuprica

# PROJECT CLIENT, STAKEHOLDERS, TECHNICAL ADVISOR

Client:

Mark Lamer, P.E.

Technical Advisor:

John Tingerthal, P.E.

## Stakeholders

- Citizens of Kuprica
- NAU ASCE-Student Chapter
- Mark Lamer, P.E.

*Pictures taken from http://nau.edu/CEFNS/Engineering/Civil-Environmental/Directory/*

# PROJECT DESCRIPTION

- 1:10 scale model requested to compete for contract
- Best performing model will build full-scale bridge
- Bridge to span Nogo River in Kuprica
- Field Conditions
  - Organic soil conditions
  - Long tropical rainy season
  - Construction during dry season

Figure 1: Tropical river similar to Nogo River [1]

*[1] Picture taken from girlgonegalivanting.com*

# TECHNICAL CONSTRAINTS

- Constraints Established from Rules
  - Steel
  - Max Bridge Dimensions: 5'(H)x5'(W)
  - Members cannot exceed 3'x6"x4"
  - Maximum construction time (45 minutes)
  - Penalties applied as weight or time
  - Judged on aesthetics, construction economy, stiffness, structural efficiency

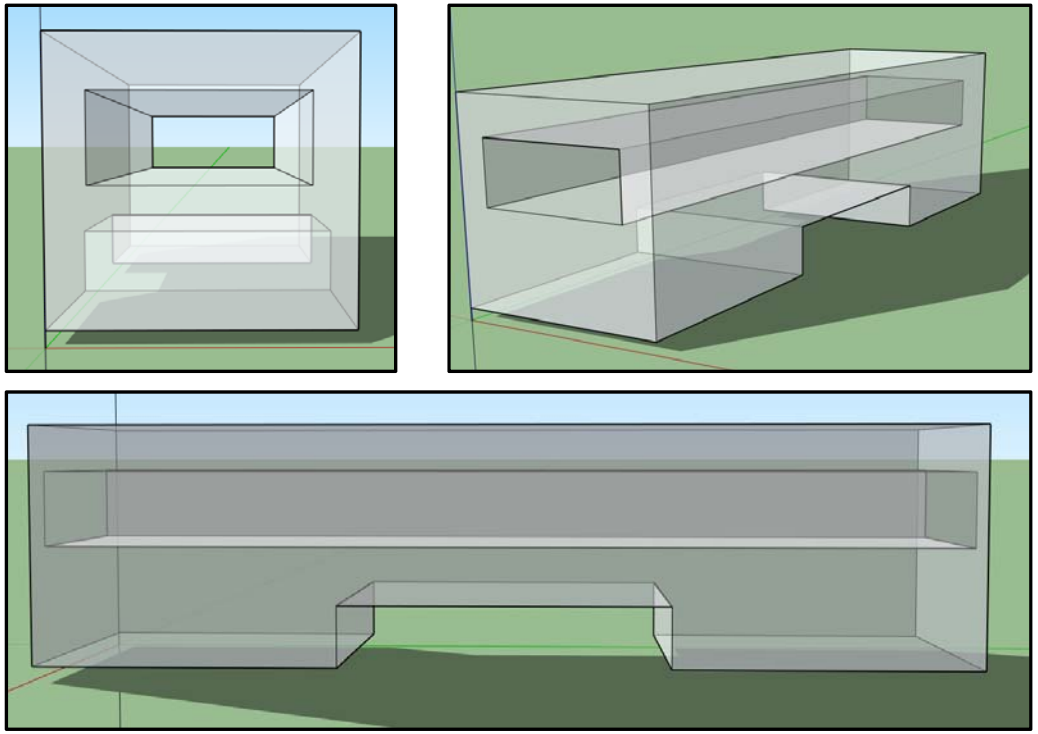


Figure 2: Bridge Envelopes, developed using SketchUp

# BROADER IMPACTS

## Fictional Impacts

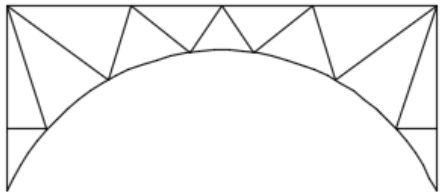
- Increased commerce in Kuprica
- Transport of building materials
- Causeway
- Temporary detours

## Actual Impacts

- Established and furthered relations with sponsors
- Provided mentorship to future members of the steel bridge team
- Set a precedent for quality of project
- Generated excitement and support for the project
- Represented NAU in a regional competition

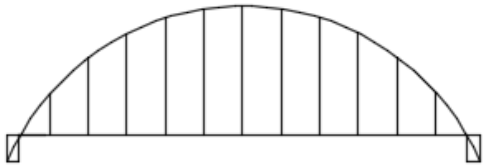
# TRUSS DESIGN ALTERNATIVES

CAMELBACK

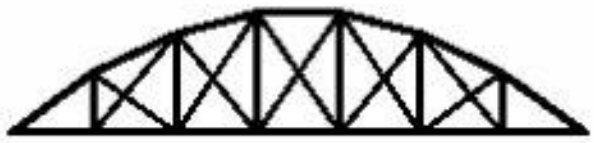


UNDER ARCH

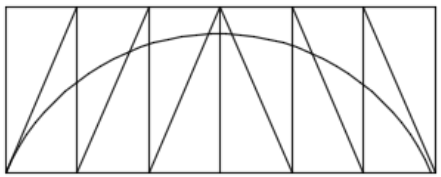
WARREN



ARCH WITH MID DECKING



BOWSTRING



TRUSS WITH ARCH

# DECISION MATRIX

| Criteria | Arch with Mid Decking | Camelback | Truss with Arch | **Warren** | Bowstring with Crosses | Under Arch |
|---|---|---|---|---|---|---|
| Strength (25%) | 5 | 5 | 5 | **5** | 5 | 5 |
| Lightness (30%) | 3 | 4 | 1 | **5** | 1 | 2 |
| Aesthetics (10%) | 5 | 3 | 2 | **1** | 3 | 4 |
| Constructability (20%) | 2 | 4 | 1 | **5** | 3 | 2 |
| Fabrication (15%) | 4 | 5 | 2 | **5** | 1 | 3 |
| Final Score | 3.65 | 4.3 | 2.25 | **4.6** | 2.6 | 3.1 |

Table 1: Decision Matrix

# TRUSS ANALYSIS: MEMBER SIZING

- Iterative process used to determine member sizing
- Limit of two member sizes for simplicity
- Selected Members
  - Standard ¾" Pipe (203 LF)
  - Standard ½" Pipe (102 LF)

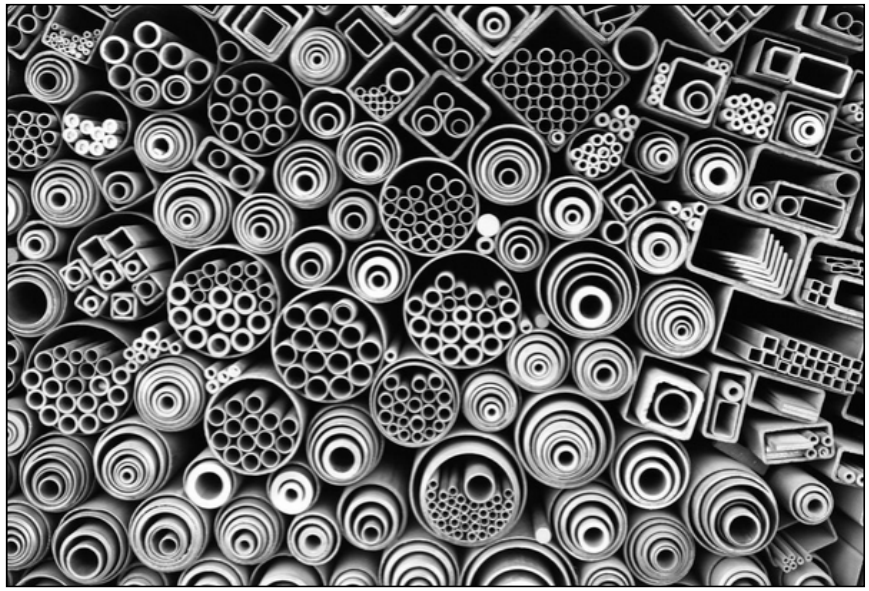
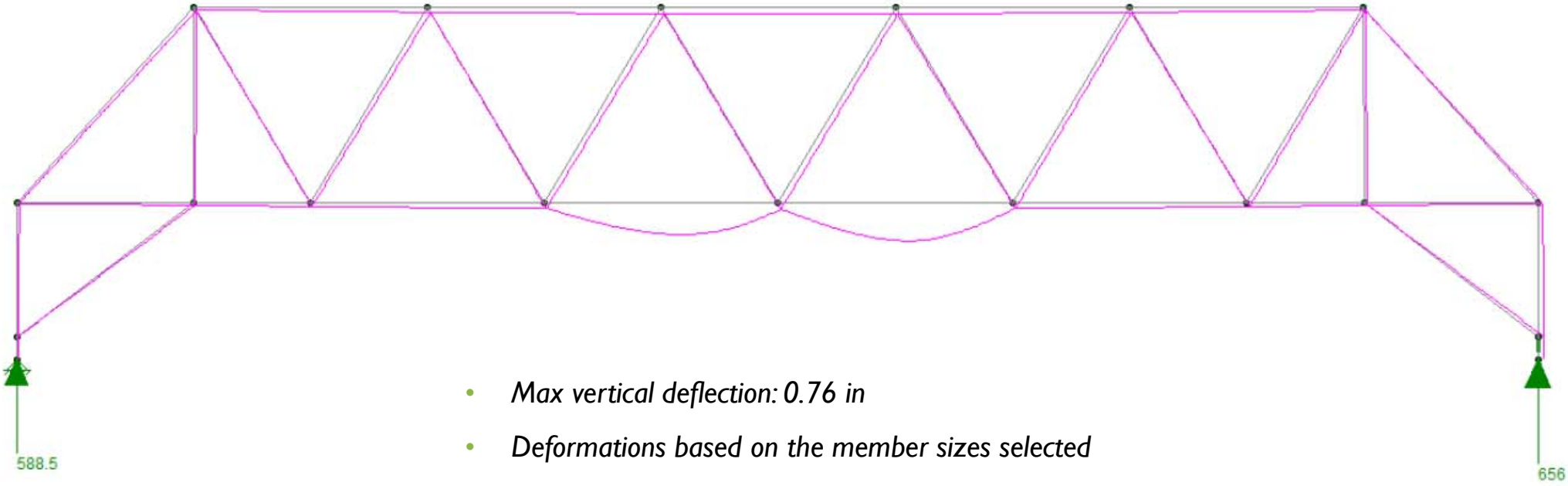


Figure 3: Various steel cross-sections [2]

*[2] Picture taken from http://akfaport.com/portfolio/iron-steel*

# TRUSS ANALYSIS: RISA 2D




- *Max vertical deflection: 0.76 in*
- *Deformations based on the member sizes selected*
- *Vertical exaggeration of deformation: 10*

*Image developed using RISA 2D*

# CONNECTION ANALYSIS: BOLTS

## Bolt Sizing

- Bolt size based on:
  - Pipe outer diameter
  - Gusset plate thickness
  - Handling ease
- Bolt size: $^{5}/_{16}$ " with $1 - {}^{1}/_{2}$ " thread length

## Bolt Edge Distances

- Bolt spacing determined per AISC
  - Edge spacing: AISC J3.3 (0.75")
  - Bolt hole to bolt hole: AISC T.J3.4 (1.0")

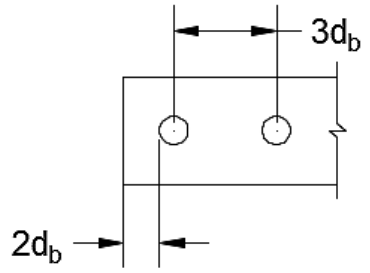



Figure 4: Bold edge distances, developed using AutoCAD

# CONNECTION ANALYSIS: BEARING CAPACITY

## Knowns:

- Max tension: 2,100 lbs
- Max compression: 1,976 lbs
- Plate thickness = $^{5}/_{16}$"
- Bolt diameter = $^{5}/_{16}$"

## Assumptions:

- Plate strength: 65,000 psi
- Bolt strength: 150,000 psi

Figure 5: Gusset connections [3]

*[3] Picture provided by Steel Bridge Team*

# CONNECTION ANALYSIS: BEARING CAPACITY

- Calculated Bearing Stress:
  - 10,750 psi
- $\phi R_n$ (Connection Strength)
  - $R_n = 2.4 \times \text{Tension} \times \text{Bolt Area}$
  - $\phi$=0.75 (For single bolts)
  - $\phi R_n$=11,426 psi

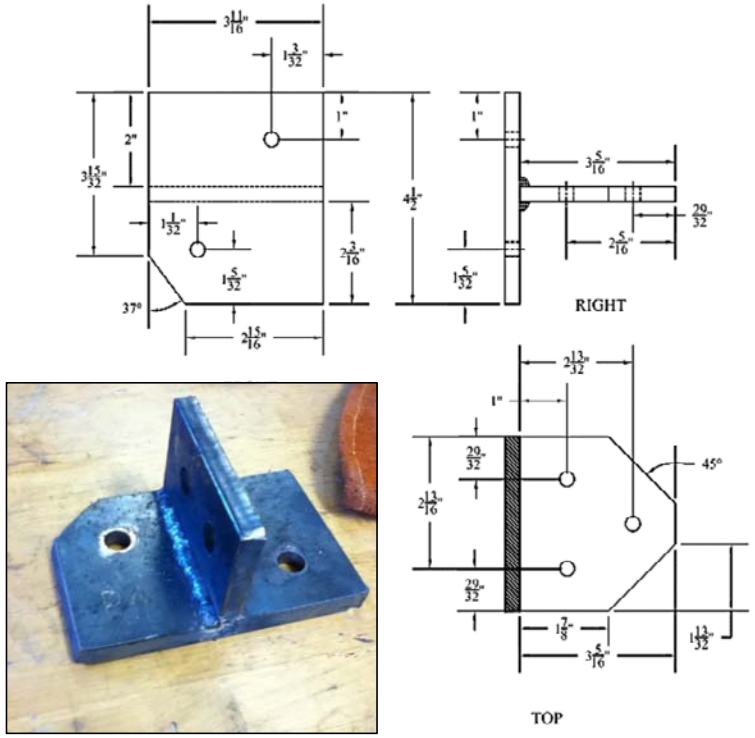
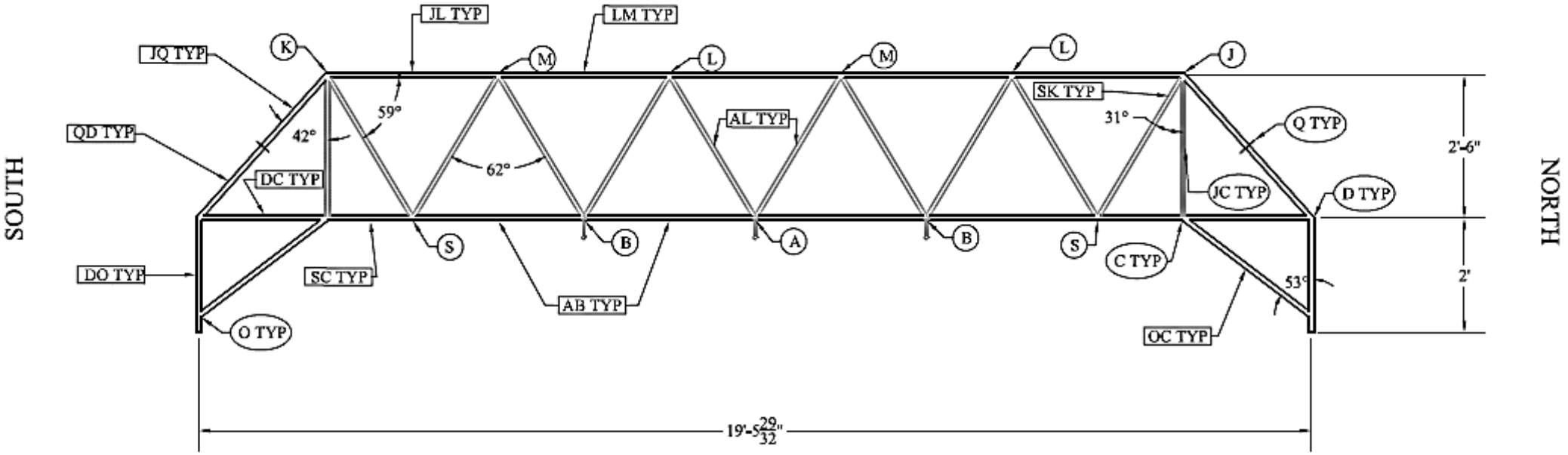



Figure 6: Welded gusset connections [3]

*[3] Picture provided by Steel Bridge Team, Image developed using AutoCAD*

# 100% DESIGN PLANS - ELEVATION

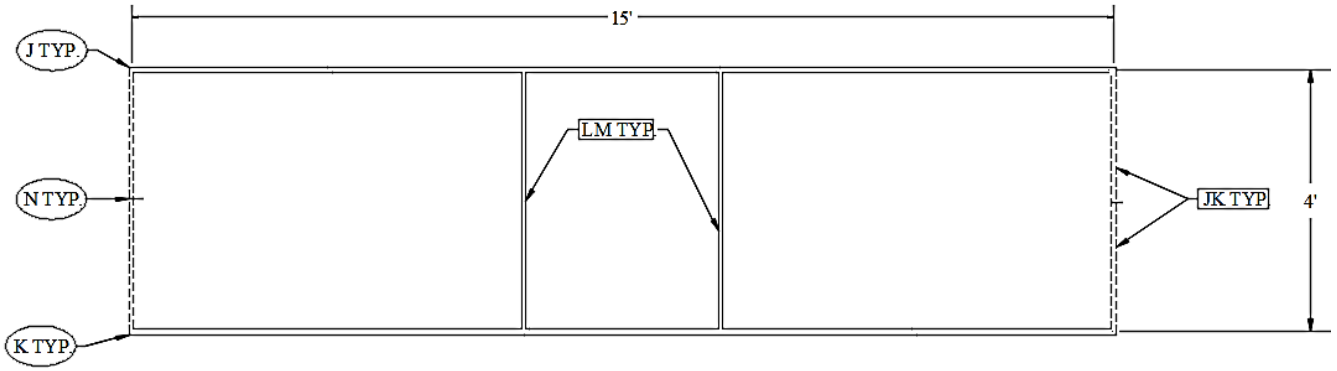



ELEVATION VIEW

*Image developed using AutoCAD 2015*

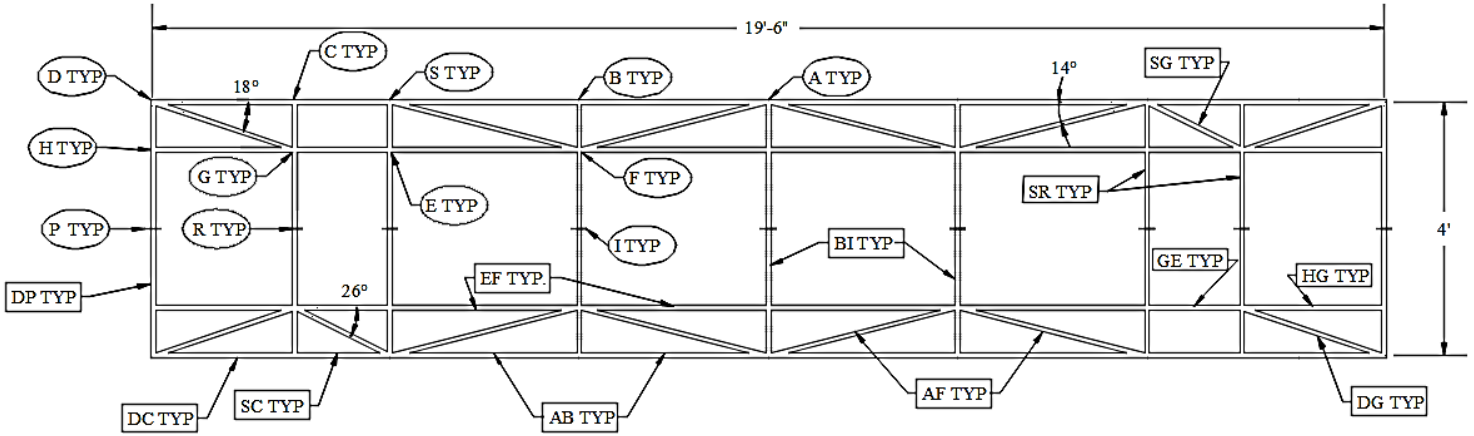
# 100% DESIGN PLANS – DECKING AND CROSS BRACING





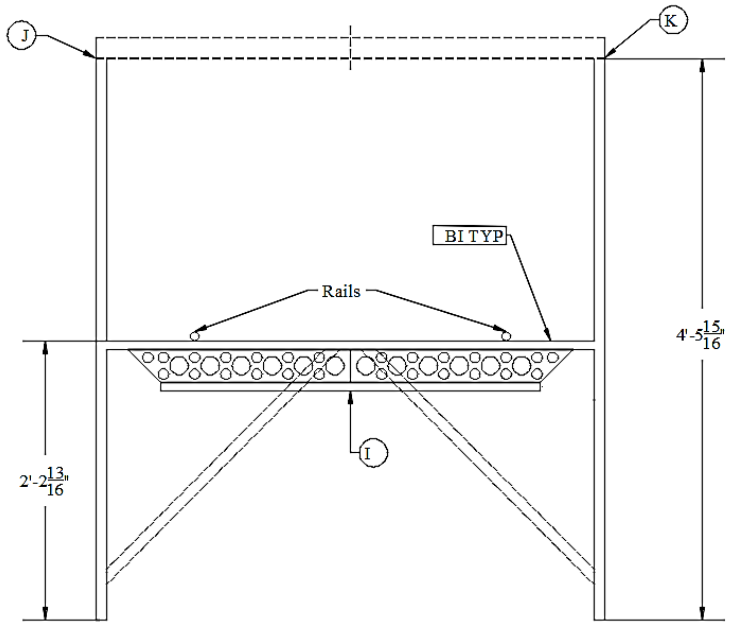

CROSS BRACING
PLAN VIEW

*Images developed using AutoCAD 2015*

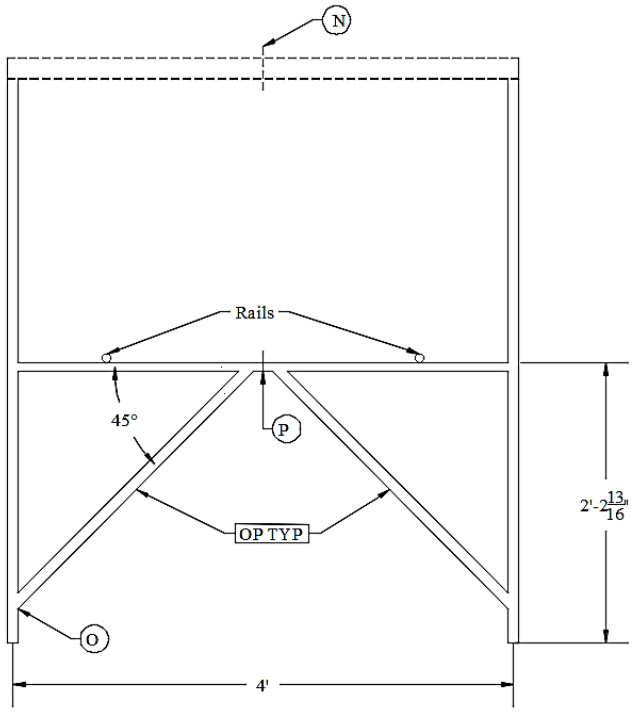



DECKING
PLAN VIEW

# 100% DESIGN PLANS – CROSS SECTIONS



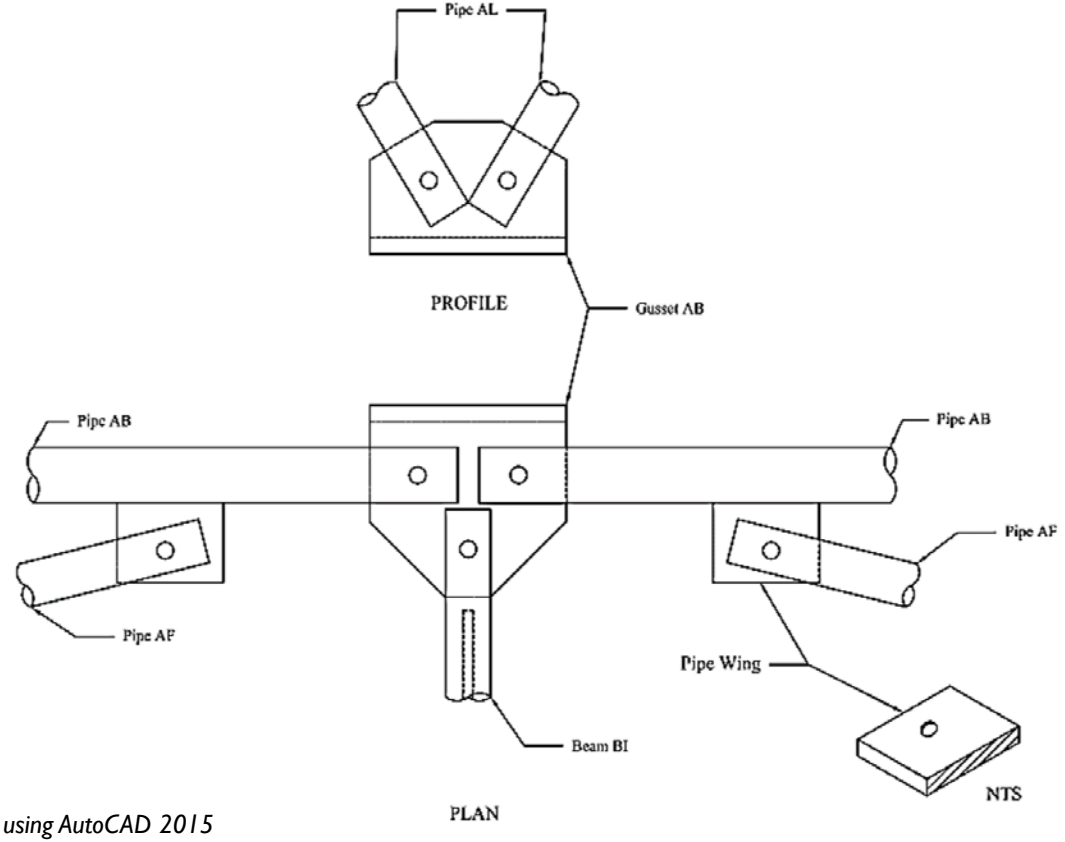

MID-SPAN CROSS SECTION

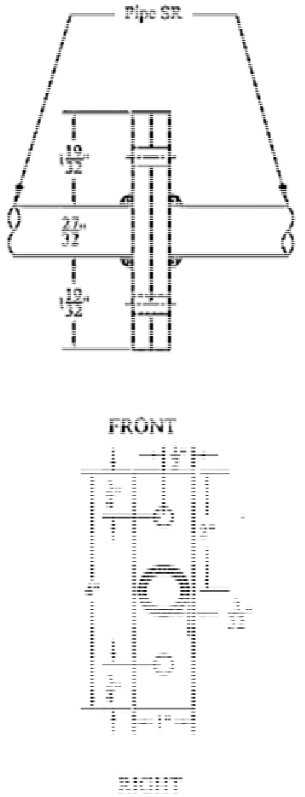



END-SPAN CROSS SECTION

*Images developed using AutoCAD 2015*

# 100% DESIGN PLANS - CONNECTIONS




*Images developed using AutoCAD 2015*

# FABRICATION

Figure 7: Wendy Clark and Cody Elliot Welding [3]

Figure 8: Noel Cruz cutting slots [3]

Figure 9: Lauren Stadelmeier cutting members [3]


Figure 10: Wendy Clark cutting gussets [3]

*[3] Pictures provided by Steel Bridge Team*

# PSWC CONFERENCE COMPETITION - CONSTRUCTION

Figure 11: Bridge construction [3]

Figure 12: Bridge construction [3]

Figure 13: Bridge construction [3]

Figure 14: Bridge construction final product [3]

*[3] Pictures provided by Steel Bridge Team*

# PSWC CONFERENCE COMPETITION - LOADING

Figure 15: Lateral load test [3]

Figure 16: Vertical load test [3]

Figure 17: Vertical load test [3]

*[3] Pictures provided by Steel Bridge Team*

# PSWC CONFERENCE COMPETITION- RESULTS

- Build Time: 42.36 min
- Lateral Deflection:  0 in
- Load Held: 2,100 lbs

- Penalties
  - Dimensional: 1
  - Tool Drops: 15
  - Time penalties: 3

Figure 18:  Bridge failure [3]

*[3] Picture provided by Steel Bridge Team*

# EXPLANATION OF FAILURE

- Fabrication error led to moment in top chords
- Little deflection prior to failure
- Decking still fully intact and operational
- Cross bracing on top was reduced due to construction time restraints

Figure 19: Right connection pipe failure [3]

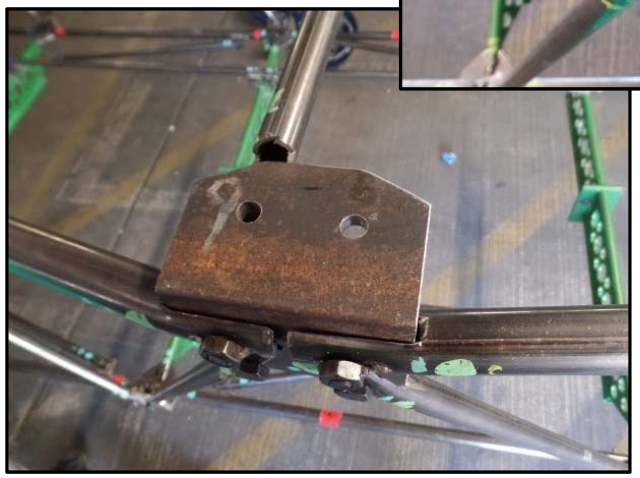


Figure 20: Left connection pipe failure [3]

*[3] Pictures provided by Steel Bridge Team*

# PROJECT PERSONNEL HOURS

| Position | Hours |
|---|---|
| Project Manger | 287 |
| Design Engineer | 275 |
| Safety Engineer | 311 |
| Scheduling Engineer | 298 |
| Intern | 300 |
| **Total Hours** | **1471** |

Table 2: Allocation of hours

- Design: 200 hours
- Fabrication: 750 hours
- Remaining 521 hours allocated to meetings, documents, etc.

# ACKNOWLEDGMENTS

Special thanks to our sponsors, mentees, and everyone else who contributed to the project!

We built this bridge together!

*Mentees:*

*Ashlee Anderson, Sabrina Ballard, Matt Rodgers, Kaitlin Vandaveer*

*Cody Elliot, Brian Jouflas, Andrew Lamer & Mingus Union High School students, Gerjen Slim, NAU Mechanical Fabrication Shop*

*Advisors:*

*John Tingerthal, Mark Lamer, Charles Schlinger, Thomas Nelson*

# THANK YOU

## QUESTIONS?