

# Connecting Communities in Bolivia

## La Marca Suspension Bridge



**Bridges to  
Prosperity**

Craig Stevens  
Scott Walls  
2/17/2020

# Lessons Learned in Bolivia



Dancing is cool, and well, Scott can dance!

# Lessons Learned in Bolivia

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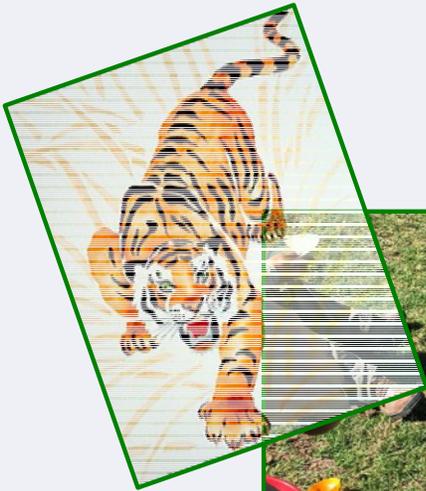


Careful with the water!

# Lessons Learned in Bolivia

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Careful with the milk!



# Lessons Learned in Bolivia

My bathroom

Or...you will end up in the bathroom!



# Lessons Learned in Bolivia

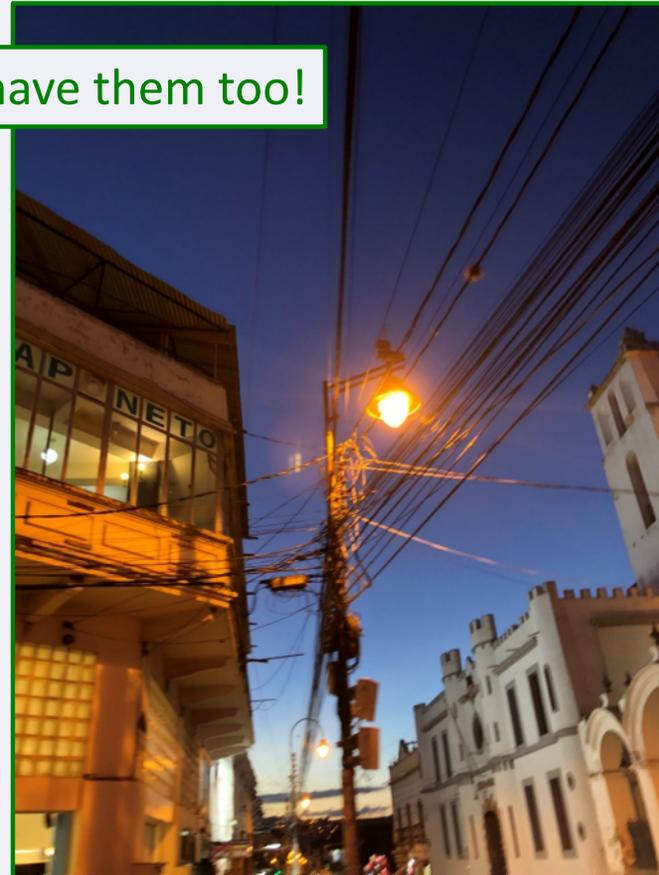
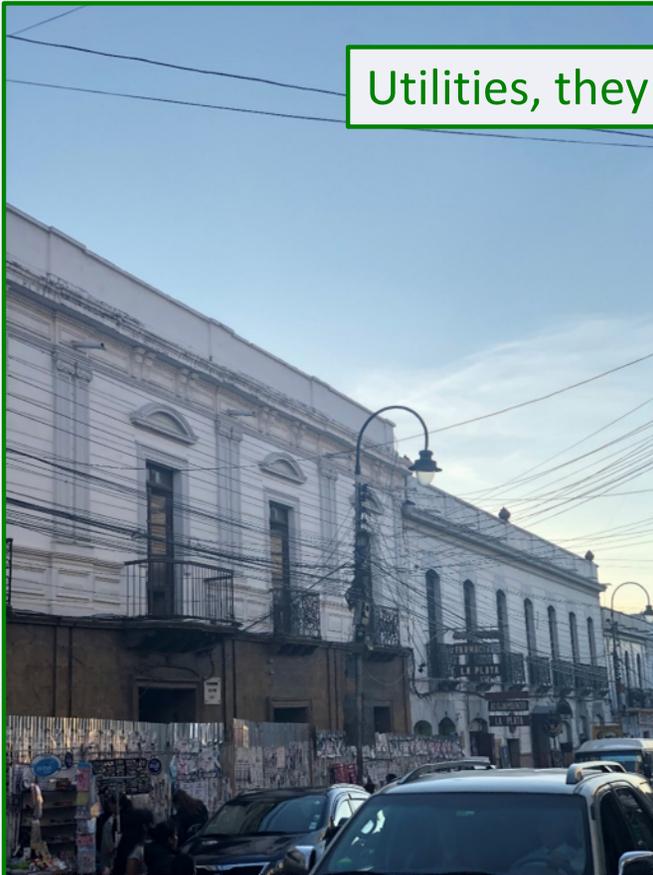


Craig is here!

The problem...these guys walked by.

# Lessons Learned in Bolivia

Utilities, they have them too!



# Lessons Learned in Bolivia

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I am grateful for my commute to work!



# Why we did it!

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Meet Miguel and Alejandro



# Why we did it!

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Meet their parents Mr. and Mrs. Pedro and their family farm.



# Why we did it!

They are preparing “Milk from the cow” for our team.



# Why we did it!

Earlier the family brought the team corn and cheese.



Milk and cheese make Craig happy.

# Why we did it!



That is me and  
Scott struggling

Alejandro's and Miguel's future commute to school

# Why we did it!

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They continue past the cows...

# Why we did it!

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Over and through smaller creeks



# Why we did it!

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Only to have to cross this!



# Why we did it!

Others crossing the same stream!





The commute to school!

La Marca

House

River

Azurduy

School

# Why we did it!



# Bridges to Prosperity

## Why bridges?

Footbridges provide access to health care, education and economic opportunity; they transform the way people plan for and invest in their future.



**Bridges to  
Prosperity**



## Reliable access to health care & schools improves wellness & education levels.

Easier access to healthcare leads to increased care-seeking behavior; when a community has safe access to a clinic, there is an 18% increase in visits. In an emergency, easier access means a more likely positive outcome. A healthier individual is better able to work or attend school.



# ONE OUT OF EVERY SEVEN PEOPLE

IN THE DEVELOPING  
world lack safe  
**TRANSPORTATION**  
access to  
**ESSENTIAL SERVICES**

Source: World Bank



# B2P Program

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## B2P Staff

bridge design,  
materials,  
substructure  
construction



## Local Leadership

bridge site,  
accommodations, local  
volunteers, future  
maintenance



## Industry Team

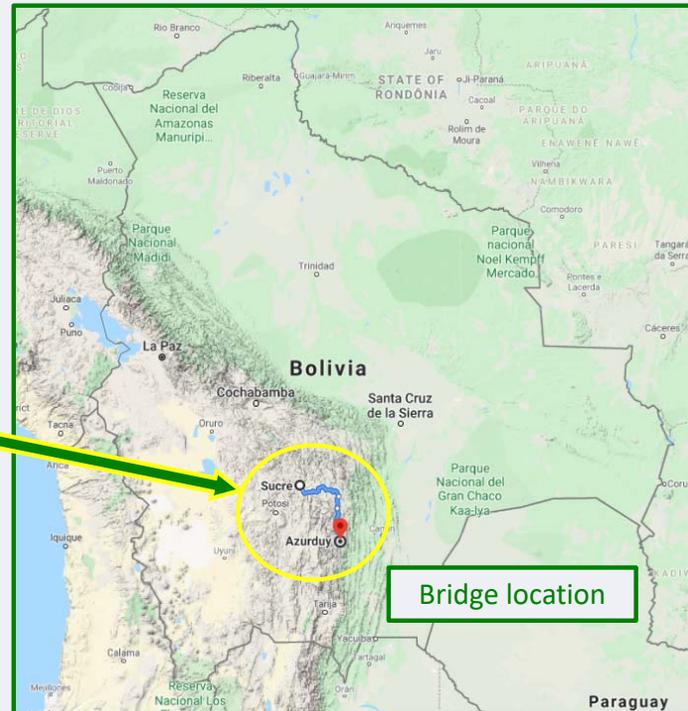
funding, traveling  
volunteers,  
superstructure  
construction

# Who Participated?

- 11 volunteers from across the US
  - Delaware to California
- Mix of State DOT's, Private Design Firms and Steel Fabricators
- Many building materials donated
- Travel expenses incurred by volunteers
- DeIDOT utilized annual time for 2 week trip



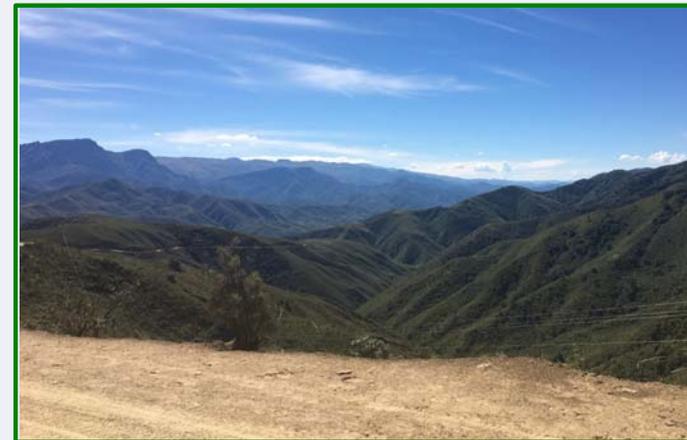
# Where is Bolivia?



- 3 flights (PHL ->MIA -> Sucre)
- Sucre: ~9,200' Elev.
- 2 days of travel – one way

# Sucre to Azurduy

- 9 hour drive
- The scenery was better than the roads



Warning signs?  
Guardrail?  
Oncoming traffic?

# Our Accommodations

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# The Food!



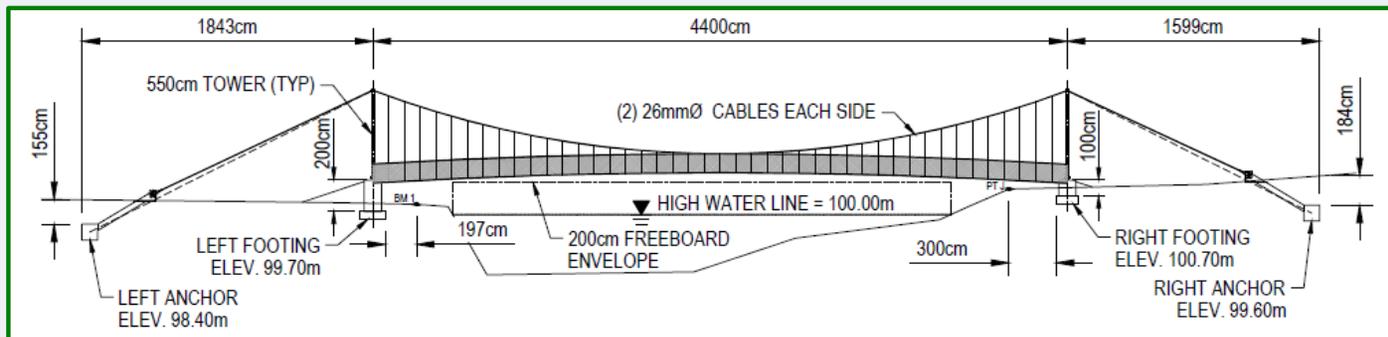
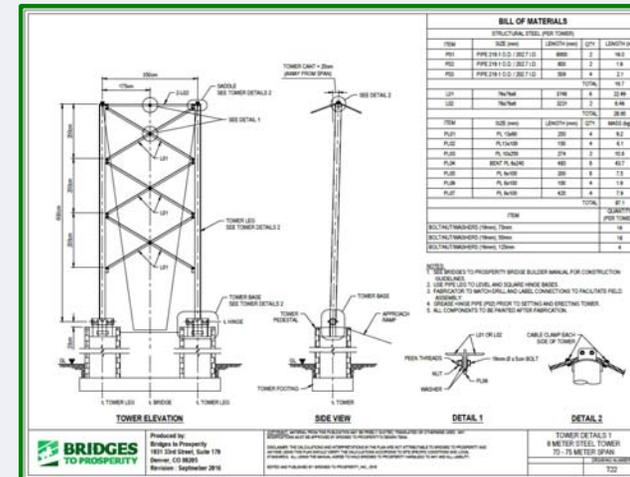
- Food purchased in Sucre and brought with us
- Lots of potatoes, yucca, plantains, and eggs

Just the bare necessities!!

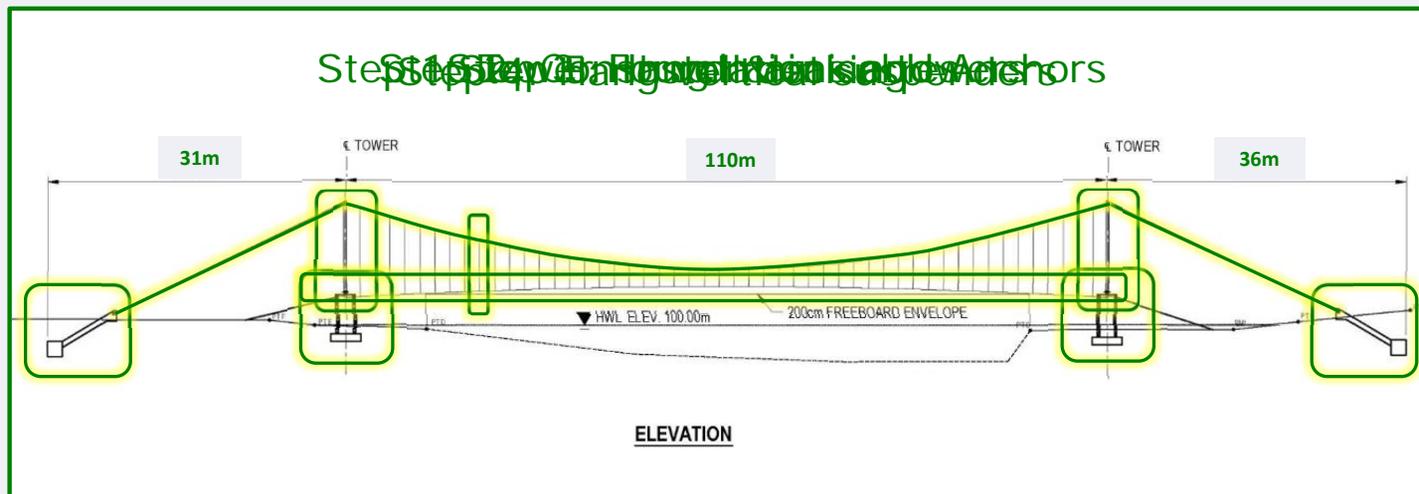


# The Bridge Plans

- Steel suspension footbridge
- Design completed by engineers at B2P
- Given electronic plans prior to leaving
- Team met via video conference calls to discuss construction sequence
- Craig and Scott were tasked with creating a construction schedule...



# The Bridge



- 5 Primary Steps of Construction
- Main Span: 110m (361 ft)
- Total Length: 177m (580 ft)

# The Plan

- First day of work: April 15, 2019
- Planned Inauguration Day: April 26, 2019
  - It must be done because our visa expires and we're leaving!
- 11 days to work, including Easter
- Craig and I were tasked with creating a construction schedule...



Document Name	Bolivia Construction Schedule	Week 1							Week 2							Post Construction	KEY:	Brief Description of Tasks
		Mon	Tue	Wed	Thur	Fri	Sat	Sun	Mon	Tue	Wed	Thur	Fri	Sat	Mon			
16	Fabricate Suspenders																	Measure, Cut and bend, .
17	Fabricate and Check Restraint Cables																	Measure, Mark, Stage
18	Fabricate Swing Assemblies,																	Attach suspender to Crossbeams and nailers
19	Install Swing Assemblies to Restaint Cable (Right Tower)																	2 on ground, two on tower
20	Install Swing Assemblies to Restaint Cable (Left Tower)																	2 on ground, two on tower
21	Prepare Decking																	Measure, cut and lay out (Drill if able)
22	Place Decking (Right Tower)																	Start from each tower and go across
23	Place Decking (Left Tower)																	Start from each tower and go across
23	Place Guy Wires (East and West)????																	Guy wires and assemblies have to be prepped, measures, cut, and placed.
23	Prep & Install Fencing																	Lay each side of fencing out, cut if needed, and place curb on fencing.
23	Place Ramp Placement, Clean up																	Mix and place the access ramp to tie into the deck, also clean up.
23	Travel To Airport (Sucre), Stay the night																	We shall drive 9 hours to Sucre.
23	Fly Home (long lay-over in Santa Cruz)																	Fly home.

...nothing went per the schedule...

# Foundation Excavation

- Completed prior to arrival
- B2P staff and locals excavate by hand
- ~ 10 ft (3m) deep for anchorages
- ~ 3.5 ft (1m) deep for towers



Anchorage for main cables



Spread footing for towers

# Foundation Construction

- Completed prior to arrival
- Rebar installed and concrete placed in lifts
- Tower foundation raised to stay out of flood zone
  - Ramp created to match existing walking path elevation



Anchorage for main cables



Ramp to tower foundation

# Foundation Construction

- Concrete placed and cured prior to arrival
- Assumed concrete strength for design  $\sim 1,450$  psi



Anchorage for main cables



Path to tower foundation

# Foundation Challenges

## First Construction Issue!

- Groundwater reached during west anchor excavation
- Needed to create counterweight for anchorage
- Plan revision: Rock gabions constructed and placed by hand



Local volunteers work breaking rocks with sledge hammers and placing rocks for the gabions. CRAZY HARD WORK!

# Tower Assembly

- Tower fabricated, painted, and shipped from Cochabamba
- Tower moved in place by hand
  - (Craig and I were in Miami 😊)
- Assembled at the site, ~33 ft tall (10m)



Layout of tower



Bolting together the tower assemblies

# Tower Lift Preparation

- Careful preparation was taken to rig scaffolding correctly
- Safety always #1 priority for B2P
- Remember nearest major hospital is back in Sucre ... 9 hour drive away



# Tower Lift



Towers hoisted with the help of a come-along

# Tower Cant

- Cant set prior to lifting tower
- Ensured plumb tower at final condition



Calculated using complex technology



# Cables

- Moved by hand only, no heavy equipment
- Each cable had to be un-coiled
- Anchored on one side
- Pulled up and over one tower
- Pulled across the river
- Pulled up and over the second tower
- Anchored to the remaining side



# Another Lesson Learned...

Every Day is Cable Day!!!!

- 4 main cables
  - 1 ¼" diameter
  - ~4 lb/ft
  - ~3000 lb each cable
- 2 wind guy cables
  - ¾" diameter
- 2 restraint cables (1/2" diameter)
- 1 safety cable (1" diameter)



Norfolk, VA



Anchoring cable

# Another Lesson Learned...

- Pulling cable is an honest day of work



Everything is covered in grease



That's a gasoline soaked rag...



Craig is tired!

# Cable Clamps



# Initial Cable Sag

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Initially cables are pulled by hand to get them around the anchor blocks.

# Setting Cable Sag



Attach a temporary cable to the main cable and winch the cable to set the sag. Reset and repeat multiple times.



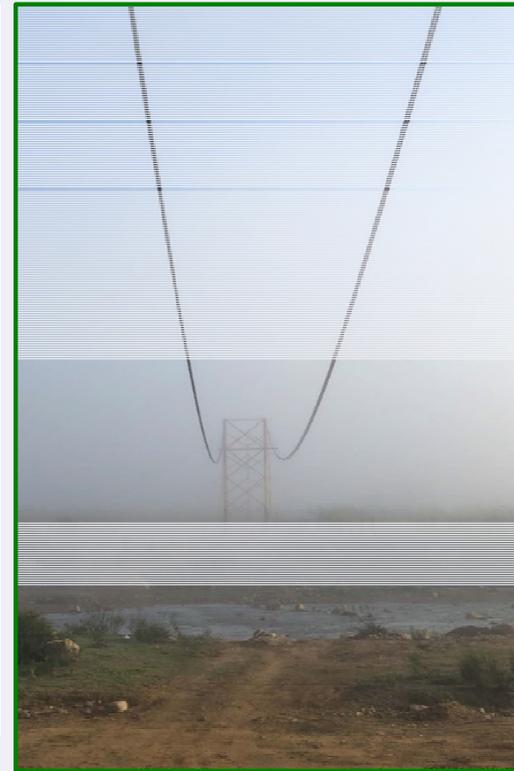
The easy job...

# Final Cable Sag

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View of the cables the following morning.  
Equal sag in each cable per plan



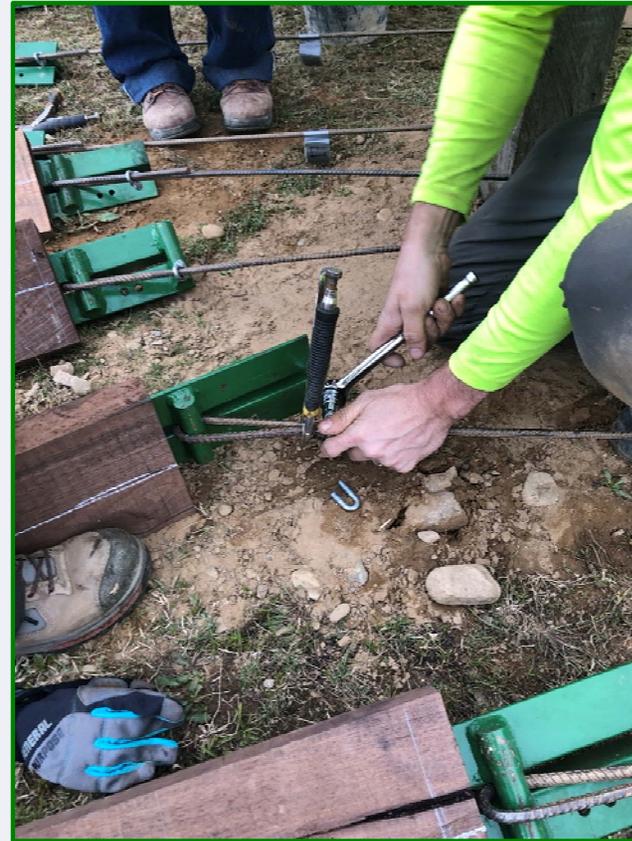
# Fabricating Suspenders

- ½" diameter rebar
- Cut to length and bent with hook at top and bottom
- 110 pairs of suspenders
- Each pair a different length!



# Assembling Floor Beams

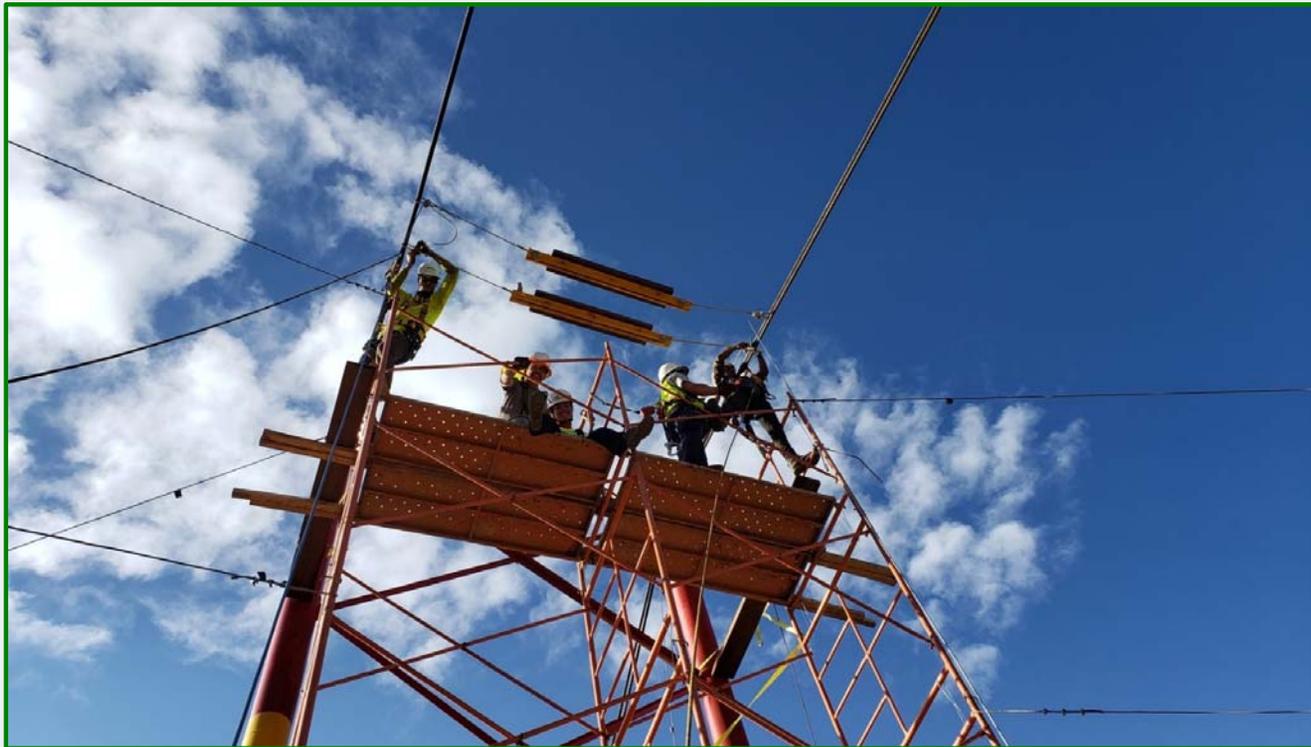
- 110 floor beams
- 2 suspenders for each
- 5' wide
- Organization was key to meet bridge profile
- Flag color had to be in the correct orientation!



# Hanging Floor Beams

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- Attached top of suspender assembly to main cables
- “Launched” floor beams from the tower toward main span



# Hanging Floor Beams

- Top of suspender is clamped to the restraint cable at specific distances to create equal spacing along cables sag
- Restraint cable pulled from center span to launch floor beams



# Hanging Floor Beams

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Craig and I at the top of the scaffolding

# Preparing Deck Boards

- 168 deck boards
- Cut all timber to length
- Square off edges
- Predrill 1,108 holes



# Placing Deck Boards

- Stagger deck boards lengthwise
- Most efficient to work as a team



# Completed Decking

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# Wind Guys

- Wind guys provide lateral support
- Attached to every 5<sup>th</sup> floor beam



# Fencing

- Chain link fence
- Rolled out, measured, cut, and painted off the bridge
- Carried onto the bridge in long sections



# Completed Bridge!

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# Completed Bridge!

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# Inauguration Day

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# Inauguration Day

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# Inauguration Day

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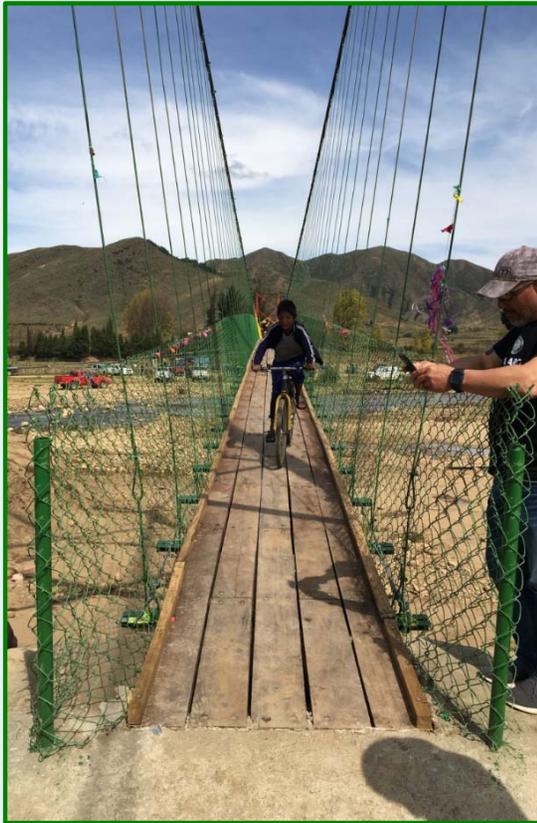
# Load Testing

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# Open to Traffic!

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# Alejandro's Approval!

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# Who made this possible?

- National Steel Bridge Alliance (NSBA) partnership with B2P
- You!
  - Golf Fundraiser
    - Jonathan's Landing Golf Course (2018 and 2019)
    - Annual event each fall
  - GoFundMe Donations



# What's Next?

- Jon Tice, DelDOT Bridge
- April 2020
- Rwanda, Africa
- 35m suspension bridge



