DelDOT Bridge Competition 2019

Deck Arch Truss Bridge

Shockwave

Caesar Rodney High School

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Christopher Harris

Table of Contents

Abstract

This was our second year doing this bridge competition and because of that, we had a much easier time divvying up the tasks each of us would have to complete in order to do well in the competition. Jake and Brady researched the bridge and found the Deck Arch design that we would be working with. The most prominent issue being the length of the bridge, we all figured there needed to be more strength in the center of the bridge but this caused issues on the ends of the bridge that showed themselves after the first test. While the bridge was different from last year's simple Truss design; the new deck arch made new problems while also keeping some of the same problems as the simple truss from last year's competition. Just like last year the bridge needed effective strength at the ends of the bridge (where it touches the PITSCO tester) so we added cross supports to prevent the end from breaking because it only had the vertical supports which bowed and snapped under the pressure.

Shockwave Proposal

Introduction

Team Shockwave consists of Brady Phillips, Jake Stant, and Reign Stevens. We were in last year's competition and won second place with our design. Each of us have a background in Calculus and all three of us have taken CAD classes and drawn up designs for various purposes such as houses, bridges, and mechanical parts.

Body

The Science Behind a Deck Arch Truss Bridge:

Tension is nearly absent when an arch is built but it starts to become more and more of an issue as the length of the road increases. This happens because an arch bridge relies on compression for the majority of its strength; using its arch as a means to take the load and split it onto the two abutments on each end of the bridge. They were used countless times in ancient Roman times because of the minimal resources were needed to make it along with its incredible strength over short to medium distances. Which meant they could make small arches that connected to each other for miles--very useful for their aqueducts.

Challenges:

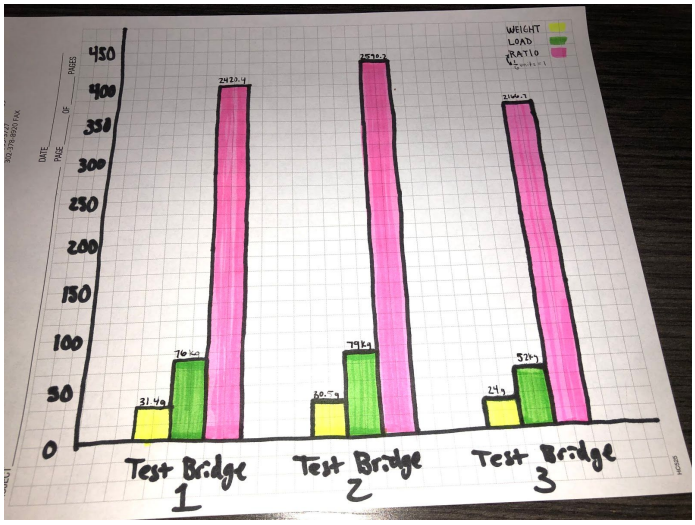
We faced various challenges with the majority of them surfacing after our first test. We had trouble deciding how to make the ends of the bridge as strong as possible because that is where the bridge was the weakest. We found that we built the bridge without taking into account that our strong lamented pieces at each end of the bridge were not in direct content with the block being used to test the bridge. We also found that our diagonal pieces in the area between

the road and arch were not as strong as they could have been, had we oriented them in a more ergonomic fashion.

Data Table:

Bridge Name	Weight (g)	Load Held (kg)	Ratio
Test Bridge 1	31.4g	76kg	2420.4
Test Bridge 2	30.5g	79kg	2590.2
Test Bridge 3	24g	52kg	2166.7

Graphic Representation of Tests:



Graph of the results from each test bridge

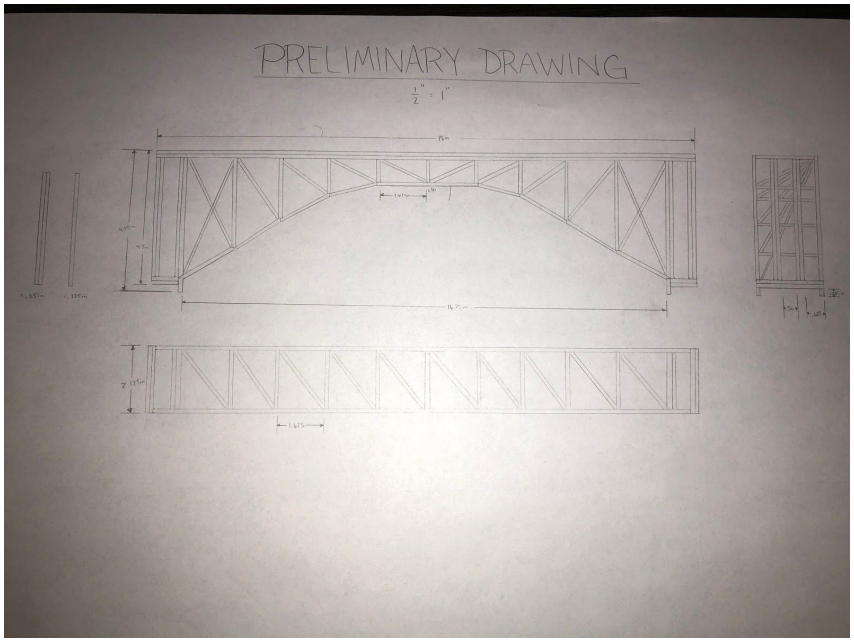
Supporting Calculations:

Bridge 1: 76kgs → 76,000g / 31.4g = 2,420.4 Ratio

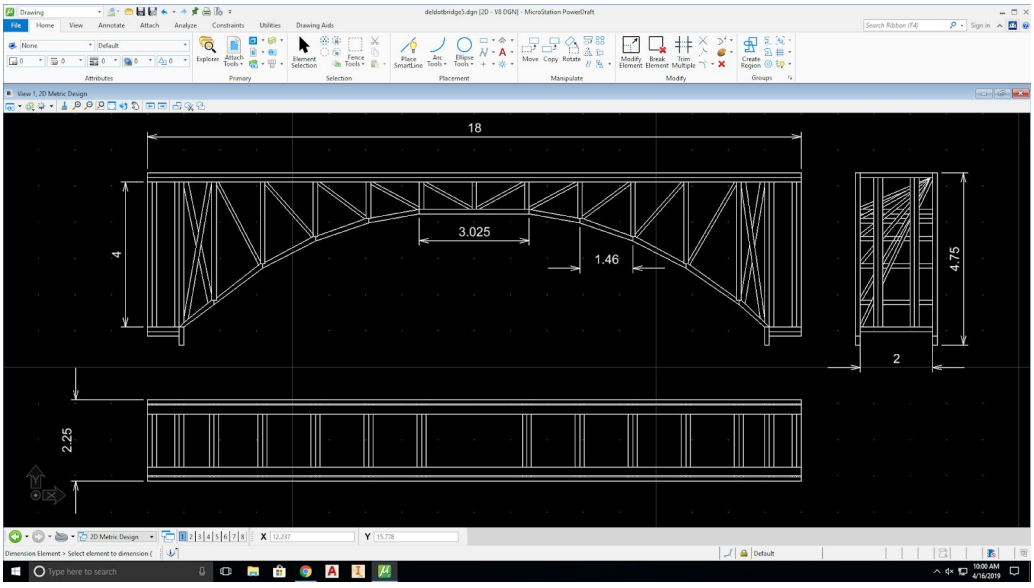
Bridge 2: 79kgs → 79,000g / 30.5g = 2,590.2 Ratio

Bridge 3: 52kgs → 52,000g / 24g = 2,166.7 Ratio

Scaled Drawings:

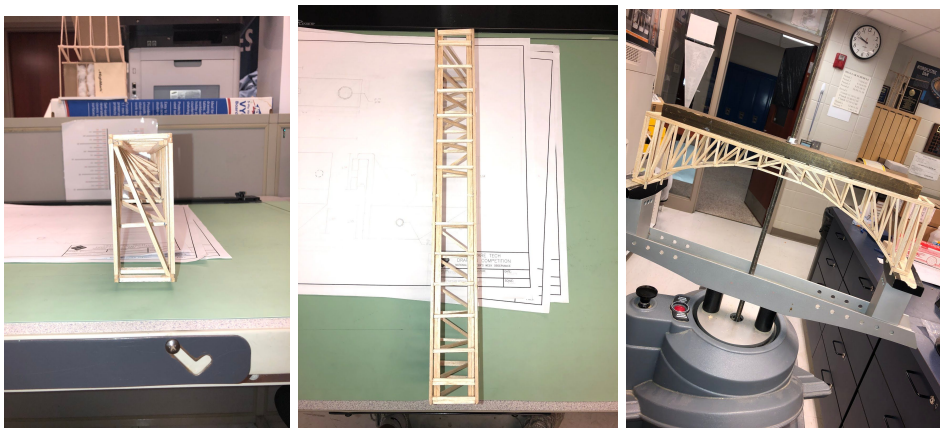


Full scale hand drawing



Microstation full scale drawing

Team and Bridge Pictures:



Bridge 1 just before testing

Reign working on ModelSmart3D (left), Brady doing scaled drawings (right)

Testing Environment and Improvements:

Our CAD teacher has a PITSCO tester in his classroom so we were able to accurately test our bridge with all of the testing specifications listed in the instructions. These tests showed us that the parts of our bridge touching the tester are weak and need to distribute weight to the abutments in a more effective way than beforehand.

Building Process Complications:

The only significant building complication we had was the time it took to build; specifically the arch whose awkward shape is quite difficult to get right using just balsa wood. One thing we did to make the entire process easier is we built the bridge upside down rather than right side up so we were not fighting gravity in a sense. It made the cross sections and arch much easier to glue together because of how everything fell into place rather than us forcing it to fall into place.

Conclusions

As a whole our bridge is very successful but we will only know that if it does well come competition day. However, given the time and thought put into it we hope to do quite well. This year our team took scheduling and made it first priority because we knew the due date for the proposal, as well as the day of competition, will both come faster than we think. To be more specific to the bridge, we learned more about the science of an arch bridge. In the beginning we chose to test three different designs. One was more successful than the others and for our final bridge, the one we will use for the competition, we chose the second test bridge because it had a better ratio than the others.

Acknowledgements

- ★ Christopher Harris: Supplied us with the same tester that is used in the competition, and also helped us get acquainted with the new software.
- ★ "I hereby certify that the majority of the ideas, design, and work was originated and performed by the students, with limited assistance by adults, as described above."
- ★ Signature: *Christopher Harris*

Appendices

Scheduling and Accomplishments:

As far as scheduling went we were able to mimic a lot of what we did last year with weekly meetings where we would either research arch trusses, work on our powerpoint/proposal, or test our own bridge. Last year we had a sprint at the end of our marathon because of us underestimating how long the proposal would take. Now that we have that prior knowledge we are trying to multitask as much as possible by doing the proposal as we test and do research for our finished bridge. Hopefully the lack of procrastination this time around will give us more leeway and maybe even a whole extra week to look over everything and make sure it is ready to present and do well come competition day.

Daily Journal:

- **February 11th**
  - Material kit arrival
- **March 1st-March 8th**
  - Brady: Researched and did measurements for first test bridge
- **March 8th-March 14th**
  - Brady: Drew up the first test bridge in the Bentley software
- **March 14th-March 17th**
  - Brady: Built our first test bridge
  - Comments: “Hard to make a strong arch with all the joints along the arch” -Brady
- **March 18th**

- ➢ Brady: Tested first bridge in CAD class and drew some sketches in his notepad to visualize the strengths and weaknesses of our bridge
- ➢ Started our second test bridge
- ➢ Comments: “We have to find a better way to distribute the weight at the two abutments of the bridge because that is where it broke first” -Brady

❖ **March 21st**

- ➢ Reign: Started on Proposal and powerpoint
- ➢ Comments: “we could put a cross section in at the abustments of the bridge so that the weight is put into the arch and transformed into compression. That way the stress is not on the vertical beams as much.”

❖ **March 28th**

- ➢ All Members: Did everything in the proposal from the title page to the body of the proposal

❖ **March 29th**

- ➢ All Members: Did from the conclusion to the daily journal of the proposal

❖ **April 3rd**

- ➢ Tested second bridge
- ➢ Started third and final test bridge

❖ **April 6th**

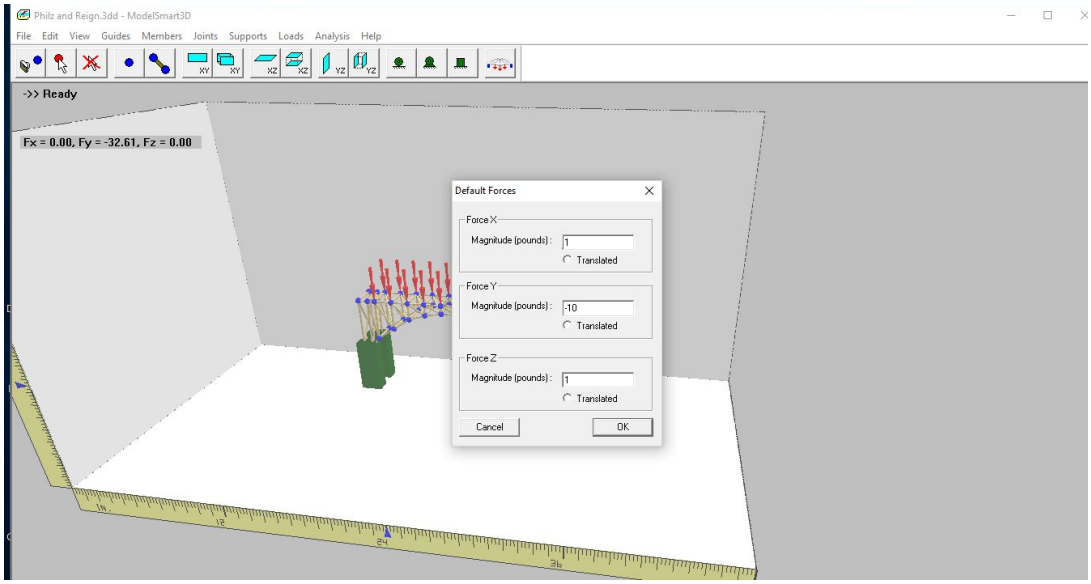
- ➢ Powerpoint Finished

❖ **April 8th**

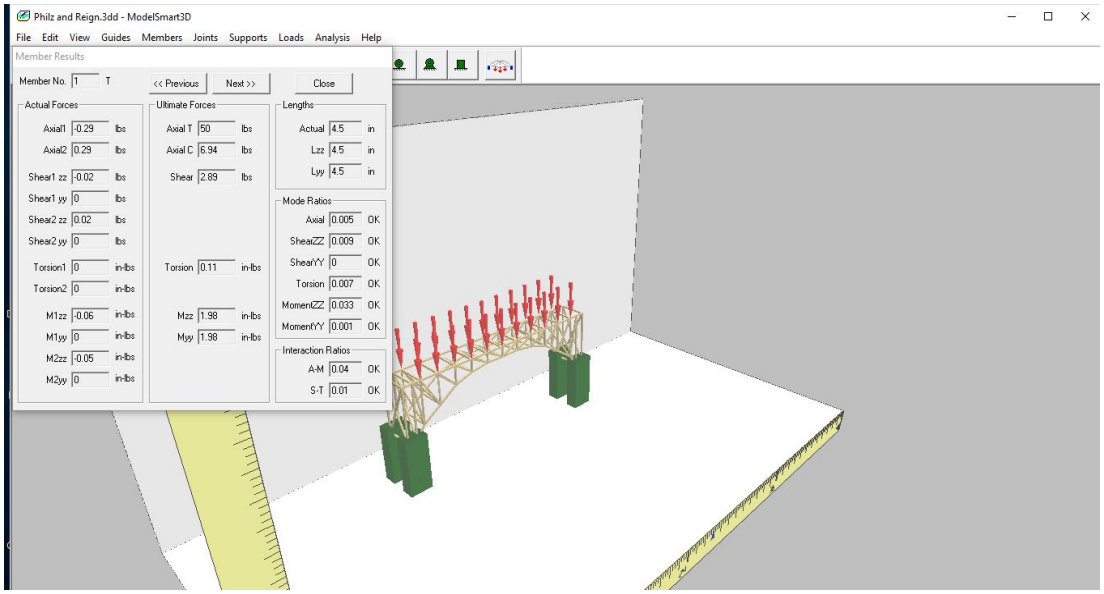
- ➢ Brady: Finished Microstation drawings

- **April 10th**
  - Brady and Reign: finished 2nd testing bridge
- **April 12th**
  - Reign: Completed the Model Smart 3D work, including screenshots
- **April 15th**
  - Tested last bridge
- **April 16th**
  - Finalizing proposal and presentation
- **April 17th**
  - Reviewing proposal and slideshow
  - Sending proposal into DelDOT

Design Software Pictures (ModelSmart 3D):

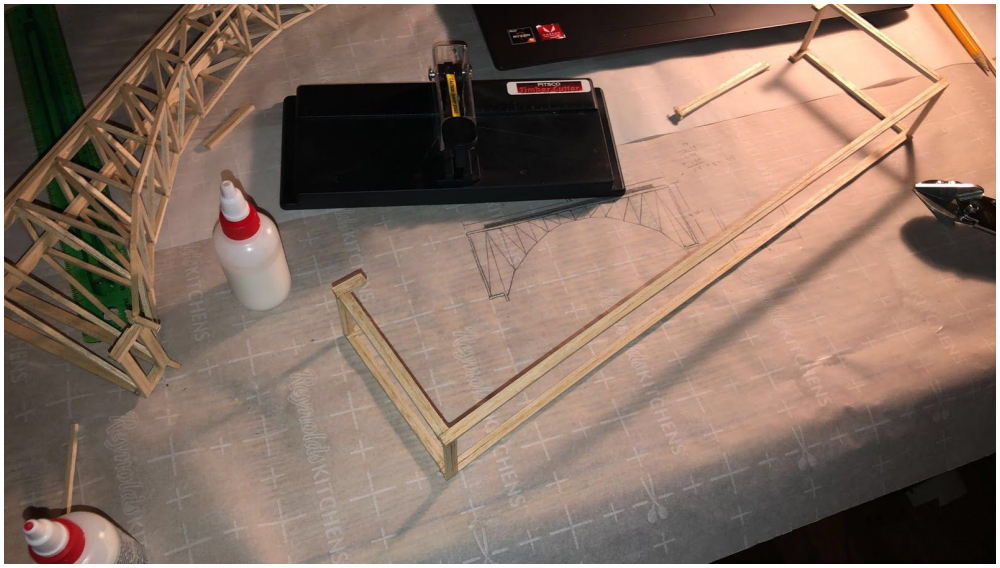


ModelSmart Load



ModelSmart member stress

Photos During Construction:



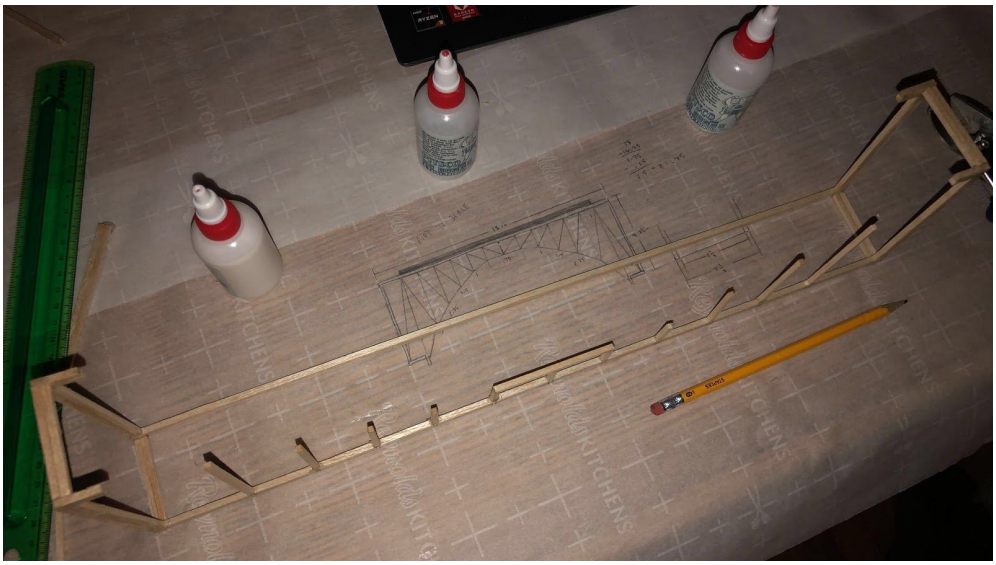
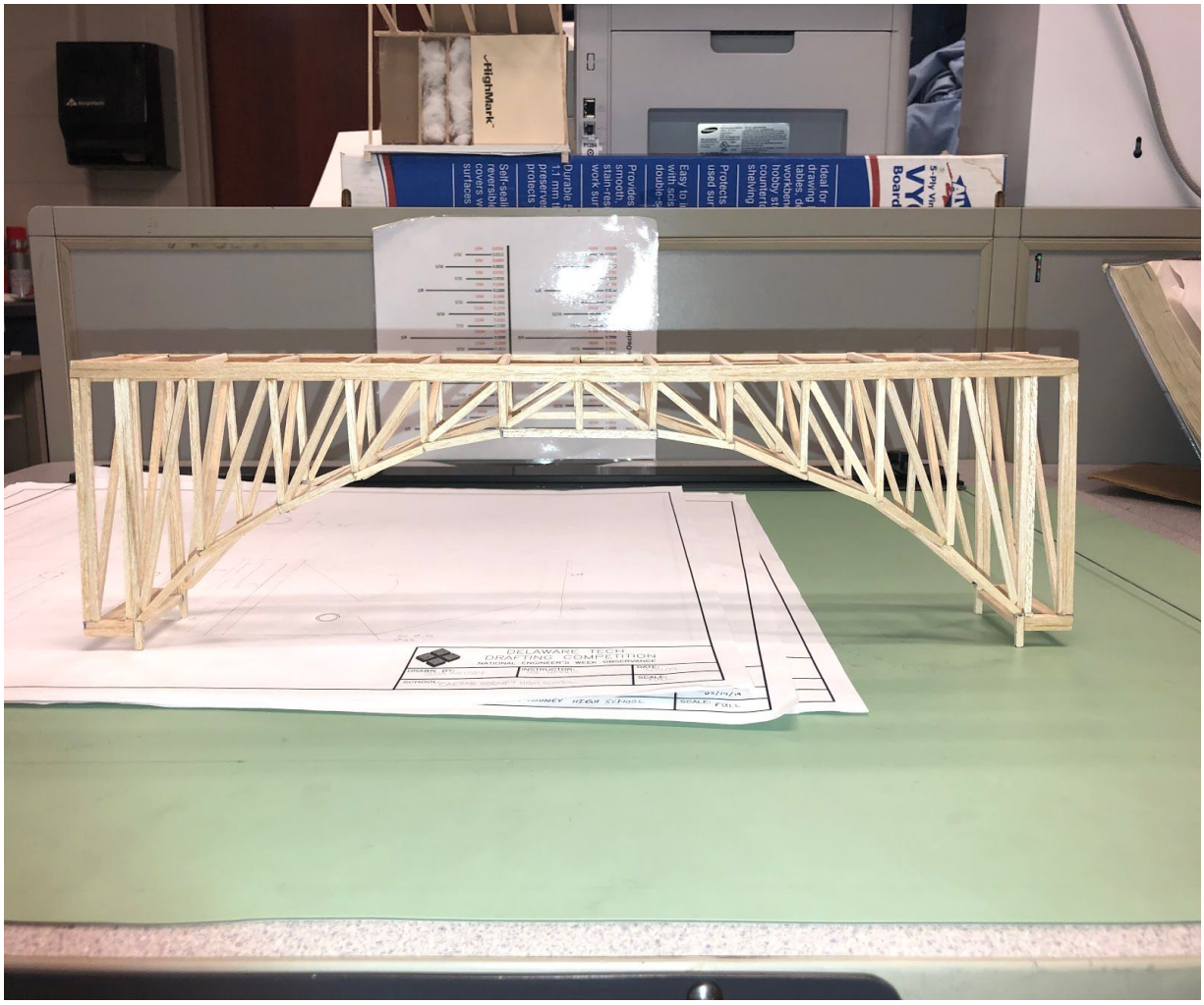


Photo After Construction:



Bibliography

https://science.howstuffworks.com/engineering/civil/bridge5.htm