Bridge, Bridge, Bridges, and
More Bridges

Background Research

There have been multiple tests similar to this science fair project. Many of them have been seeing which bridge made out of toothpicks holds the most weight. In this experiment, instead of using toothpicks, the bridges are made from popsicle sticks and Balsa wood. The types of bridges in this experiment will include; Suspension, Arch, Truss, and Beam. All of these bridges are used for different and similar things. One would usually see a Suspension Bridge crossing long distances of ground. A beam bridge is the only one of these bridges that aren't used for traffic. Usually one would see them on a hiking trail as a beam to cross a small river. Truss bridges (which aren't built anymore) are usually used for short distances crossing (not as short as beam, but not as long as suspension). Arch bridges are used for roads. People might see them as a bridge for wildlife to cross but there are many famous arch bridges around the world. One also might see it on a hiking tail. Usually people don't know they are crossing an arch bridge unless they look at it from the side. This research is important because it tells what the bridges are used for.

A Truss bridge is easy to build (Advantages of Steel Truss Bridge Construction, 1). Even though truss bridges aren't usually used for long distances, they can go long distances and still hold a bunch of weight (Advantages of Steel Truss Bridge Construction, 1). The triangles on a Truss bridge help it support weight, that is why they are really strong (Strongest Shape in Structural Engineering, 1). A suspension bridge is designed to be flexible because of that, when a person is on it, they can feel it move (Feel the Bridge Move, 1). If they weren't flexible it would collapse when weight was put on it. Arch bridges are a pain to build. Even though they are a pain to put together, they don't have a lot of disadvantages that come with them (Advantages and Disadvantages of Arch Bridges). This research shows what the advantages of each bridge are.

Deflection- The action or process of deflecting or being defected

Question and Hypothesis

Research Question

- Which bridge deflects the least amount given a certain weight?

Hypothesis

- If a bridge is built out of popsicle sticks then the truss bridge will deflect the least because the triangles help it distribute weight.

Variables and Materials

Variables

Independent variable- Suspension, Truss, Arch, Beam
Dependent variable- How much the bridge deflects
Controlled variables- How the bridge is built, How the weight is put on, Type of weight used- barbell, How much weight is put on the bridge, popsicle sticks, glue type and amount

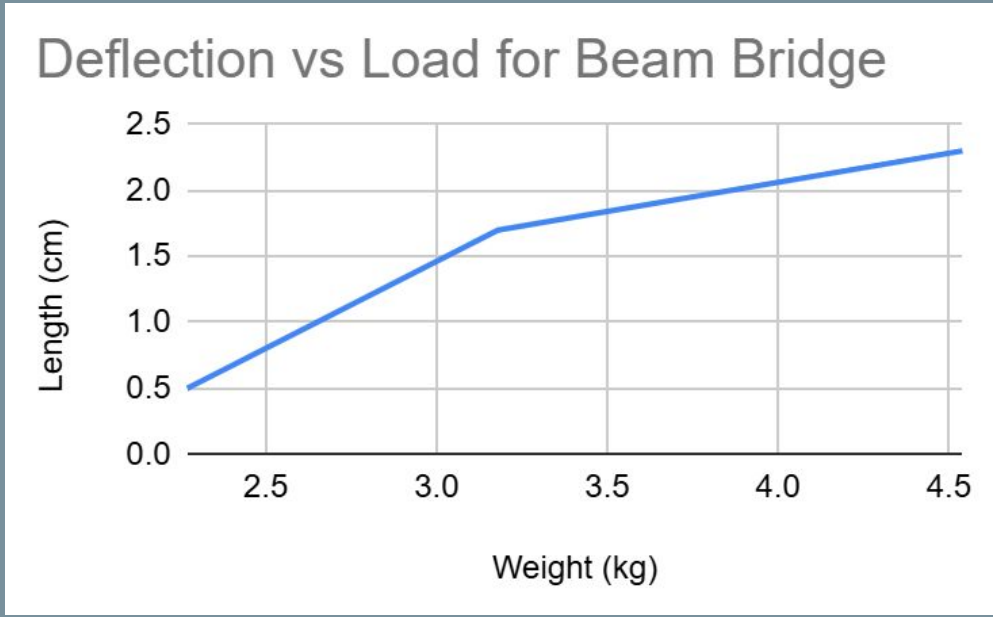
Materials

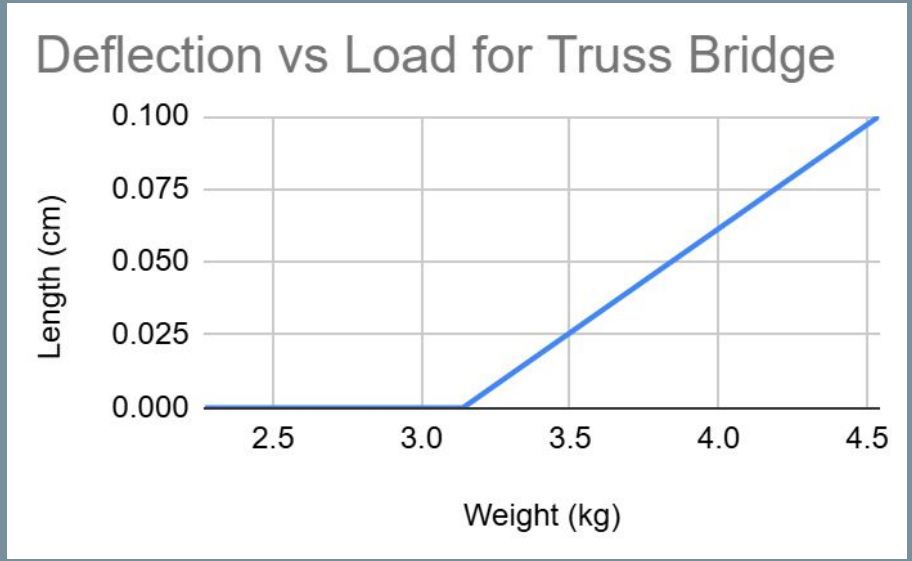
4 1in x 1ft balsa wood
Hot glue
2000 popsicle sticks (crafter- 4in)
2 kg, 4kg, and 6 kg barbell weights
Design Plans for Bridge (one for each)
1 Ruler
Pencil
Wooden Base
Wood Cutter

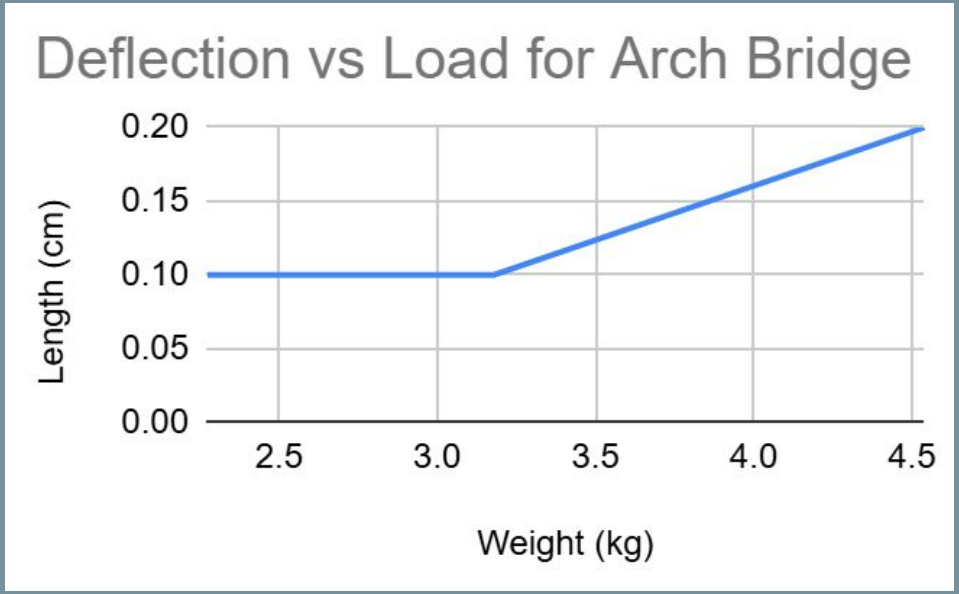
Procedure

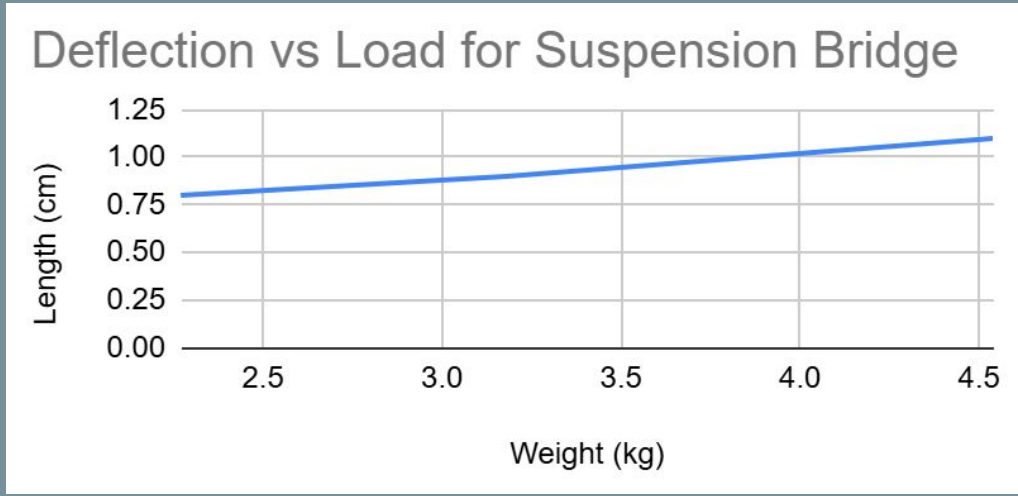
Procedure

1. Build a wooden test span, 3ft wide by 4ft long. The test span is used to support and test all of the bridges on the same span
2. Use the bridge design as a guide, following its shape and structure design
3. Construct the bridges with popsicle sticks, balsa wood, and a hot glue gun. Glue the sticks to the bridge deck to make the selected designs. The suspension bridge used extra wood for the towers and chains and threads for the suspension cable
4. Space each bridge about 20 cm from each other and attach to the test span
5. Gently set a 2k weight to the center of the bridge
6. Measure bridge deflection by placing a ruler level with the bridge deck and observe how much each bridge bent under different loads

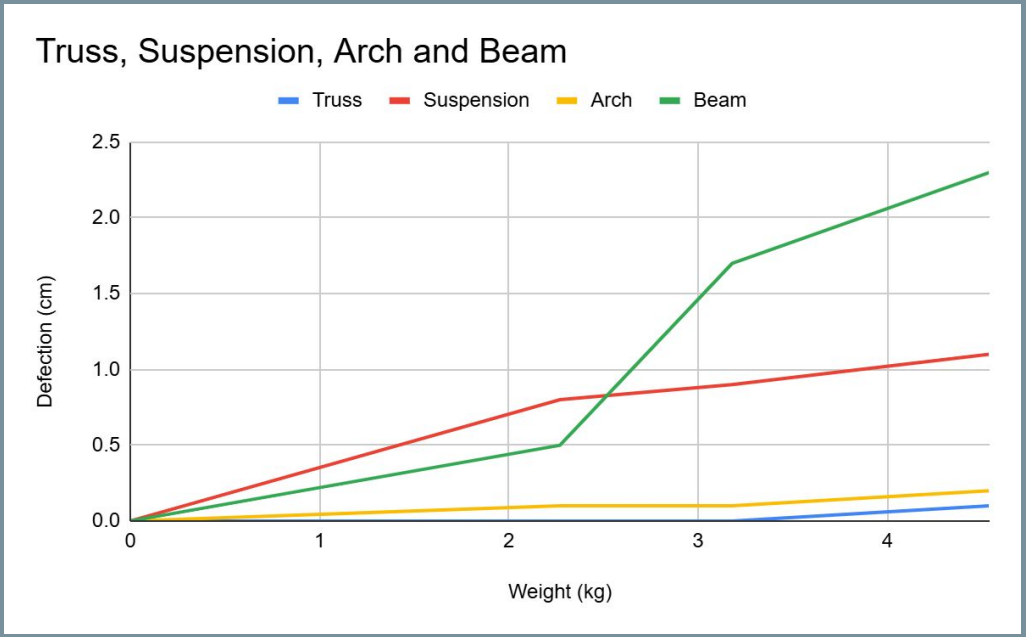

Deflection vs Load for Beam Bridge
Length (cm)
2.5
2.0
1.5
1.0
0.5
0.0
2.5
3.0
3.5
4.0
4.5
Weight (kg)


Deflection vs Load for Truss Bridge
Length (cm)
0.100
0.075
0.050
0.025
0.000
2.5
3.0
3.5
4.0
4.5
Weight (kg)


Deflection vs Load for Arch Bridge
Length (cm)
0.20
0.15
0.10
0.05
0.00
2.5
3.0
3.5
4.0
4.5
Weight (kg)


Deflection vs Load for Suspension Bridge
Length (cm)
1.25
1.00
0.75
0.50
0.25
0.00
2.5
3.0
3.5
4.0
4.5
Weight (kg)

Deflection vs Load for Four Types of Bridges				
Weight (kg)	Truss	Suspension	Arch	Beam
2.27	0	0.8	0.1	0.5
3.18	0	0.9	0.1	1.7
4.54	0.1	1.1	0.2	2.3



This graph shows deflection vs load for four different types of bridges. A bridge that is stronger defects less for any given load. A steeper slope shows more deflection happened in the bridge therefore the bridge is less stiff/ weaker. This graph shows that the unsupported beam bridge deflects the most for the maximum load. The arch and truss bridges are stronger at all data points. The suspension bridge deflects more than the beam bridge at low weights, but much less than the beam bridge at higher weights. This is because it was difficult to adjust the cables supporting the suspension bridge leaving the suspension bridge almost unsupported at low weights.

Results

This was an experiment to test how common bridge designs can strengthen a bridge as compared to the most simple design which is a straight plank. The truss bridge was constructed with a popsicle stick truss glued to the bridge with hot melt glue. As shown in the attached graph, the truss bridge defected the least for each test load meaning the truss bridge was stiffer then the simple beam bridge. The arch bridge was also constructed with popsicle sticks arches glued to the bridge with hot melt glue. The performance of the arch bridge was similar to the performance of the truss bridge. The suspension bridge was the most difficult to construct. It used strings tied to chains supported by two towers. The performance of the suspension bridge was worse than the truss and arch bridge, but that appears to have been caused by the difficulty of tightening the strings precisely. The loose strings caused the suspension bridge to be almost unsupported until higher weights where used. None of the bridges were tested until they broke because broken bridges would not have made a good exhibit for the science project. Therefore it is not known which bridge was actually the strongest or how each bridge would fail under a heavy load.

Experimental Design

Bridges will be built out of popsicle sticks and tested for how strong they are. The independent variable is the type of bridge. The dependent variable is how much the wooden beam bends. The controlled variables are the type of popsicles sticks, the type of weight, and how the weight is set on the bridge.

Conclusion

My hypothesis was that the truss bridge would deflect the least because of its triangular designs that help it distribute weight. Unlike an unsupported beam bridge, which deflected the most, the truss bridge is made up of interlocked triangles. Therefore, when a weight is added onto the truss bridge, the load is transferred through all the truss triangles as tension and compression rather than being fully unsupported/ bending. At the end of my test, my hypothesis was supported by the outcome, which was that the truss would hold the most weight. Throughout the experiment I learned that an arch bridge, which works by transferring weight onto it's curve outwards and downwards to its support, is really hard to build. Suspension bridges, which work by using high strength cable systems to support the deck and transfer its load onto towers and anchors, are stronger than they look. Also, it is really hard to build all the bridges the same size because of their different shapes and the limited amount of space I had. There are multiple things that could have gone wrong or given one bridge more of an advantage over another, some examples being that weight would not fit in the suspension or truss bridge so I had to put two plastic jars on them to be able to set the weight on top. This might have added a bit more weight to those bridges giving them a disadvantage. A lot of the time the bridge would barely move and with the materials I had, it was really hard to tell where the mark was and how much it deflected. In conclusion, the truss bridge supported the most weight with the least deflection but there are many things that I would change about this project if I were to do it again in the future.

Implications and Ideas for Future Research

This project is important for life because it helps engineers know which bridge to build for it to not collapse. For future research it would be better to build bigger bridges because some of the bridges I built would have definitely been stronger if they were two or three more inches taller. If I where to go back and do this project again I would do more research before, and make my designs better. A lot of my designs where not that great, I feel like they could have been better but for the limited supplies I had I think I did a pretty good job. If I were to do this again I would make my bridges more complicated because it would be cool to see if the complication of the design makes the bridge stronger or weaker.

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