

Concept design report

Engineering



Concept Design Report Executive Summary This project aim was to use popsicles to construct a bridge which can support considerable weight while at the same time remain aesthetically pleasing and economical. The bridge required a maximum 20 inches in length, and could not exceed 400 grams. It should follow a truss bridge design, and will be used over a river. Materials for bridge construction consisted of Popsicle sticks and Elmer's school glue. Weights and sand were used to test the load capacity. The bridge snapped suddenly at the outer edges.

Background Information: Many highway bridges built in the past have failed to match the rising needs in the modern world and as such have called for need for rehabilitation and in a number of instances, total replacement. With many bridges aging and traffic demand demands ever rising, many bridges have been rendered obsolete and non-functional in terms of structure. Such structural deficiencies have led to increased need for advanced design techniques. There is always an alternative to choose the most optimal approach to rehabilitation and replacement. Among the innovative rehabilitation and replacement techniques are the pre-fabricated bridge systems and more particularly, the ones with precast concrete deck panels. This is due to the many advantages they bring along and hence their high pay offs. Why this kind of bridges? One may ask. Bridges are used all over the world. Society is very dependent on them for traveling from one place to another effectively. Our design team recognizes the importance of bridges and we have decided to construct a model bridge using Popsicle sticks and craft glue to test the load capacity and effectiveness of our bridge. Materials for bridge construction consisted of Popsicle sticks and Elmer's glue. Materials used in construction of the bridge popsicle sticks Cutter, Paper, Elmer's WOOD GLUE, masking tape

Factors

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considered Structural Constraints The site considered should be a maximum of 12 inches across considering that this is the intended length of the bridge. The bridge was also required to lie across the two points, and its joints should lie on all the four points such that they offer support to the bridge. The weight of the bridge was capped at a maximum of 300 grams.

Construction Constraint The weight of the used glue was considered negligible. Quality Control Testing The estimated weight of sticks with glue was almost equivalent to the weight of the Popsicle sticks without glue. Two bridge models were considered in the project with their specifications as follows; Bridge 1: 115 Popsicle sticks used The weight of the bridge is about 124.9 grams. The weight supported is 4.05 pounds, which is equivalent to 1837 gms 12 inches in height The weakest part in the bridge is the base. Bridge 2: 200 Popsicle sticks used The weight of the bridge is about 232.1 grams The weight supported is 29.46 pounds which is equivalent to 13363 grams 12 inches in height The strongest part in the bridge is the underneath

Consideration of Alternatives With the help of West Point Bridge Designer Software, it was possible to narrow down design choices to the two bridges whose parameters have been provided. Each bridges design was compared against the other before eventually settling on one of the designs. Final bridge selection

Weight	Load	Load to weight ratio
Bridge 1 124.9	1837	14.7077662
Bridge 2 232.1	13363	57.5743214

Bridge 2 was selected based on its higher load to weigh ratio. Additionally, the two designs were considered with one being an X truss bridge without bottom support, and the other being an X truss which has the bottom support. Bridge 2 showed economic strength as well as structural soundness. The bridge was easily buildable and the available popsicles were sufficient to effectively design it. While its cost

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was a little higher, its aesthetics and higher load to weight ratio made it the preferred design. **Prototype Construction** The chosen design used a total of 200 Popsicle sticks to construct the bridge, and 20.1 grams of glue.

Construction took an estimated 5 hours. The bridge's upper part required some modifications due to the fact that the Popsicle sticks would not have been able to offer the same support had they been made smaller. The final bridge weight as already mentioned was 232.1 grams. **Estimated Load Capacity** The prototype bridge's estimated load bearing capacity was 25.0 pounds. However, the actual load turned out to be approximately 30 pounds.

The estimated load capacity was obtained using the West Point Bridge design test. The alteration could however have resulted from modifications in the top part of the bridge. **Prototype Load Testing** The bridge Prototype was tested through addition of weights to outer bridge truss. This was done by attaching a bucket about a third way from the end, and weights were gradually added to the bucket until the failure point was determined.

Prototype Performance and Forensic Analysis The bridge did better than anticipated. It failed at the end-points, in addition to folding in on itself on the side closer to the loads. It was concluded that the failure was a result of weaker end supports rather than the ability of the center to bear loads.

Seemingly, there was lots of force towards the outer ends making the bridge to collapse in on its own structures. The external sticks gradually bent inwards until they were eventually unable to hold the exerted weights, after which they popped off leading to failure of the entire structure. TABLES

Table 1: Data for Bridge 1 Table 2: Bridge design 2 Table 3- Weight of Popsicle Sticks

# Sticks	Weight Dry (g)	Weight Glue Wet (g)	Weight Glue Dry(g)
2	2.5	2.6	2.6
4	5.3	5.2	6.7
5	5.3	5.2	7.5
6	7.5	8.0	7.9
8	10.8	10.7	10.8
10	12.5	13.6	13.4
16			

15 16. 4 16. 2 14 17. 5 19. 1 18. 9 16 20 21. 9 21. 7 18 22. 5 24. 7 24. 4 20
25 27. 5 27. 2 Table 4: Popsicle Stick Data FIGURES Bridge Design 1 Bridge
design 2