

# Navy Bridge Live Load Challenge (High School Students)

A bridge is a structure that spans a gorge, valley, road, railroad track, body of water, or any other physical obstacle, for the purpose of providing passage over the obstacle. There are many types of bridges: beam, truss, arch, suspension and cable stayed.



**Mission:** Research, design and construct a bridge within design constraints to hold as much weight as possible.

Engineers need to consider loads when building structures. Loads are weights and forces that a structure must withstand. The dead load of a structure is the weight of the structure itself. The dead load of the bridge, for example, includes beams, cables and the deck. The live load of a structure is the weight that is added to the structure, including people, cars and the wind.

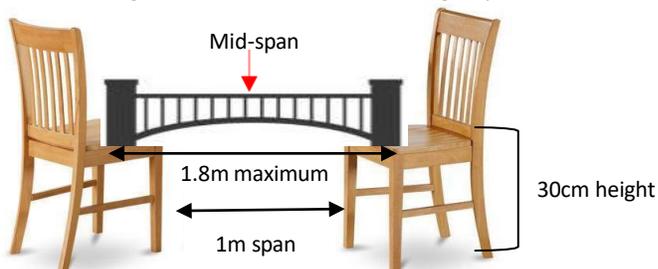
## Design Requirements:

- Bridge must span a gap of 1 meter between two support blocks. Block dimensions are 40.5cm long x 40.5 cm wide x 30 cm tall.
- Overall bridge length of  $> 1$  meter and  $\leq 1.8$  meters.
- Bridge deck must be  $\geq 14$  cm wide with the center most 30 cm clear to allow for weight to be stacked on it.
- Maximum bridge weight must not exceed 3 pounds.
- No horizontal loads allowed on the support blocks. Frictional forces are allowed.



## Load Testing:

- **Load Test Challenge:** Load testing will be done using a mechanical structure tester. Force will be applied to the center most portion of the road surface until the bridge fails.
- **Home/School Testing:** Find items to use for load testing such as rocks, bags of pea gravel, cans of food, bags of rice, workout weights and rolls of coins. Weigh each load test item and record the weight.
- Create a gorge approximately 30cm tall in a garage or outside space so that when the bridge collapses inside floors will not be damaged. This can be accomplished with chairs, stacks of books, camping coolers, or various boxes of equal height.
- Position the “gorge walls” 1 meter apart. Center your bridge on top of the gorge walls.
- Carefully add one load at a time to the top of the bridge mid-span. Ensure your feet are out of the way when adding loads and when the bridge collapses. Record load weight as you add it.
- Consider taking a video of the load testing if you are able.



## Materials:

- Unlimited popsicle sticks dimensions 11.5cm x 1cm x 0.25cm. Sticks may be mechanically altered (i.e. broken, cut). Sticks may not be soaked in any material other than water and may not be painted or coated except with markers, crayons, or colored pencils for decorative aesthetics.
- Water soluble white “Elmer’s” glue only. Yellow wood glue or glues containing resin adhesives or cement binders are not allowed.
- Wax paper as surface to construct the bridge on and allow glue to dry.

## Evaluation Criteria:

**Each bridge submitted for virtual load test will be evaluated on the following**

- Live Load Limit – Amount of weight the bridge holds before collapse.
- Live Load to Weight Ratio – Calculated with bridge total weight and live load limit. The larger the ratio the better!
- Design Aesthetic – Rated by a team of judges from 1 to 100.

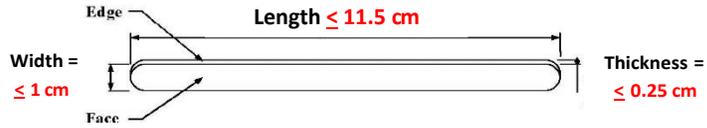


# High School Bridge Live Load Challenge Extra Information

## Materials:

1. Popsicle or Craft Sticks that meet the following measurement criteria:

- Length < 11.5 cm
- Width < 1 cm
- Thickness < 0.25 cm



Sticks **MAY** be altered in the following ways:

- Cut or notched at any angle
- Sanded to any width or shape
- Bent or curved
- Decorated using markers, crayons, or colored pencils

Sticks may **NOT** be altered in the following ways:

- Soaked in any material other than water
- Infused, painted, or coated except with markers, crayons or colored pencils for decorative purposes only.

2. Water soluble white “Elmer’s” type glue. \*Note: Yellow wood glue or any glue containing resin adhesives, or other cement binders of any kind, are NOT allowed.



## Criteria & Constraints:

1. Physical Bridge Criteria:

- Be able to span a 1 meter gap
- Overall bridge length < 1 meter but  $\geq 1.8$  meters
- Center most 60 cm clear of any supports for navigation channel and load testing.
- Continuous road/bridge deck across the bridge that is  $\geq 14$  cm wide. Center most 30 cm must allow for circular weight plates to be stacked vertically upon it.
- Total bridge weight may not exceed 3 pounds.
- No adhesive material used to attach the bridge to the support blocks.
- Ensure there is a  $\frac{1}{2}$ " hole or gap in center of road surface. This will be used to accommodate the threaded rod of a mechanical structure tester.

## Bridge Evaluation:

1. **Strength** – live load weight before failure. It’s the responsibility of engineers to create a design that is safe. For bridges, one measure of safety is the live load the bridge can support.
2. **Design Aesthetic** – Most people prefer attractive, creative, and inspirational design. If a bridge is strong but unattractive, it may not be selected over other more creative designs. Design Aesthetics Score is 1-100.

Most Unattractive Bridge – **Score 1**



Most Beautiful Bridge – **Score 100**

3. **Strength (live load) to Weight Ratio** – Your bridge will be weighed before testing. After the live load test, the live load to weight ratio will be calculated by Live Load / Bridge Weight. The larger the ratio the better!