Rules, Tools and Materials

Financial assistance is available… see Cost

Objective

Build a model bridge onsite with provided tools and materials within 3 hours with the greatest structural efficiency.

When

Friday, January 27th:	Check-In/Setup	12:00 pm - 12:30 pm
	Bridge Building	12:45 pm - 3:45 pm
	Load Testing	3:45 pm - 5:15 pm
Saturday, January 28th:	Check-In/Setup	8:00 am - 8:30 am
	Bridge Building	8:45 am - 11:45 am
	Load Testing	12:15 pm - 1:45 pm
	Awards Ceremony	1:45 pm - 2:15 pm

- If School is cancelled on Friday, Jan. 27 or dismissed early, the Battle of the Bridges will be cancelled and held on the alternate date of Feb.24
- If the Putnam is closed on Saturday, Jan. 28 due to inclement weather, the decision to close will be made by 6:00 am Saturday and a voicemail message will be placed on the Putnam's main phone number, (563) 324-1933. The snow date is Saturday, Feb. 25. If The Putnam is open, the event will be held as scheduled. Contact The Putnam Museum (563-336-7296) if a team will not be able to compete.
- On either date, if the event is cancelled and teams cannot compete on the alternate date, entry fees will be refunded. If the event is held as scheduled, entry fees will not be refunded; however pre-paid pizza and pop orders will be refunded.
- Saturday teams can **pre-order** pizza for delivery at 12 pm through the on-line registration form. Sack-lunches are allowed to be eaten in the Grand Lobby.
- Each participant will receive one bottle of water during the bridge build time.

Where

The Putnam Museum
1717 West 12th Street
Davenport, IA 52804

Categories

The event is open to any student, grade or age for either Friday or Saturday. The primary reason for the Friday session is to raise high school team participation as this is the first event of three for the **QC Tech Challenge**. A team may consist of two to four people, where all team members must be signed up on the registration form.
Categories #1-4 are competing for a team trophy and individual medals.

ALL team members must know their team name at registration.

1. Family (Any combination – kids, adults, seniors) – see Rule #10
2. Elementary (Grades 4-6)
3. Middle School (Grades 7-8)
4. High School (Grades 9-12)
5. Professional (Adults only, ≥18 years old – no additional qualifications)
   new this year, competing for a Certificate and bragging rights!

Registration limitations:

Friday: 40 teams max (any combination) limited to **8 teams from ANY ONE SCHOOL**

Saturday: 40 teams max (any combination), limited to **8 High School teams only**

Cost

$25.00 per team *Financial assistance is available… contact The Putnam Museum @ 563-336-7296*

The entry fee includes a bridge material kit and the use of a complete tool set provided at the event. This does not include entrance to the museum and/or theatre, which is not required to participate in or watch the event.

Awards

Greatest Efficiency

Awards (1st, 2nd, and 3rd) are given to teams in each of the five competitive categories for having the greatest structural or build efficiencies.

Most Innovative Design

An award for the Most Innovative Design will be given to a single team and is judged from all teams over all categories.

Schedule

Registration Deadline – Thursday, January 26th, 2017. The registration form and further details are available at www.qcesc.org by December 16, 2016 (to be announced on QCESC- FB page). Questions or concerns will be addressed by either the QCESC's Jeff Melvin (jeff.melvin@exeloncorp.com) or The Putnam Museum's Alice Loff (aloff@putnam.org).

Tools and Materials List

Figure 1: The tools and materials supplied in a build kit.

Tools

Provided:

- Hack Saw
- Pliers
- Yardstick
- Coping Saw
- Speed Square
- 2 Tubes of Glue (4g each)
- Scissors
- 12” Ruler
- ~25 Clothes pins
- Utility Knife

Available Upon Request:

- Nitrile (Non-Latex) Gloves
- Caliper
- Floral Wire
- Flat File
- Masking Tape
- 3rd tube of glue (you must turn in the 2 empty tubes)
- Square File
- String
- Graph Paper

Materials

Bridge Decking (Poster Board)
1 - 21 × $3\frac{1}{4}$-inches

~ 100 - $4\frac{1}{2} \times \frac{3}{8} \times \frac{1}{12}$-inches (Craft Sticks)

~ 100 - 6" × $\frac{3}{4} \times \frac{1}{16}$-inches (Craft Sticks)

~ 25 - $\frac{3}{8} \times \frac{1}{16}$-inches (Stir Sticks)

2 - $36 \times \frac{1}{4} \times \frac{1}{4}$ inches (Bass Wood)

2 - $24 \times \frac{3}{16} \times \frac{3}{16}$-inches (Bass Wood)

Rules:

1. Bridges must be designed to accommodate the loading apparatus and be able to support a weighted toy truck rolled across it. See the testing procedures below for more specifics.
2. The bridge span can be no greater than 24 inches or less than 19 inches, see bridge inspection checklist diagram below. Teams are provided a wood "fixture" used to model the test rig.
3. The bridge height can be no greater than 9 inches above the deck or 9 inches below the deck. A combined total height above and below the deck cannot exceed 12 inches. See bridge inspection checklist diagram below.
4. The bridge width can be no greater than 6 inches or less than 4 inches. See bridge inspection checklist diagram below.
5. All decisions by the judges are final.
6. Teams will independently build a bridge within 3 hours at the event site using a set of provided materials. Teams may ask the judges for suggestions. No pre-constructed bridge components are allowed; however, pre-drawn designs are permitted.
7. Each team will build its bridge with a provided set of standard tools. Only the provided tools may be used during the build phase and no tool, whole or in part, may be built into the bridge itself.
8. All bridges will be judged based on the highest structural efficiency rating, as calculated by,

$$\textbf{Structural Efficency} = \frac{\textbf{Maximum Load}}{\textbf{Bridge Weight}}$$

9. In the event of a structural efficiency tie, the lightest bridge wins. It is up to the team to decide on the optimum balance between weight and strength.
10. Adults are encouraged to participate in the FAMILY DIVISION only. To ensure fairness throughout the different age categories, only QCESC volunteers are to work with teams outside of the FAMILY DIVISION. **Violators risk non-refundable team disqualification.**

Testing Procedure

1. Each team's bridge is inspected by the judges for compliance with the dimensions specified in the rules.
2. The bridge weight is recorded.

Figure 3: A bridge spanning the abutments of the test rig.

3. The bridge is placed on the test rig (fig. 3).

Figure 4: The weighted toy truck.

4. To verify the bridge acts as a bridge, a weighted toy truck (fig. 4) with dimensions of ~3x2.5-inches and a weight of ~5 lb is rolled across the entire length of the bridge.
5. The loading hanger is attached to the bridge and the loading platform is hung from the hanger.
6. The load weights are placed on the loading platform incrementally until the bridge fails. The testing judges decide how to load the weight and when to use either the 2 lb or 5 lb weights while loading.
7. The maximum load that breaks the bridge is recorded.

Test Equipment

Test Rig

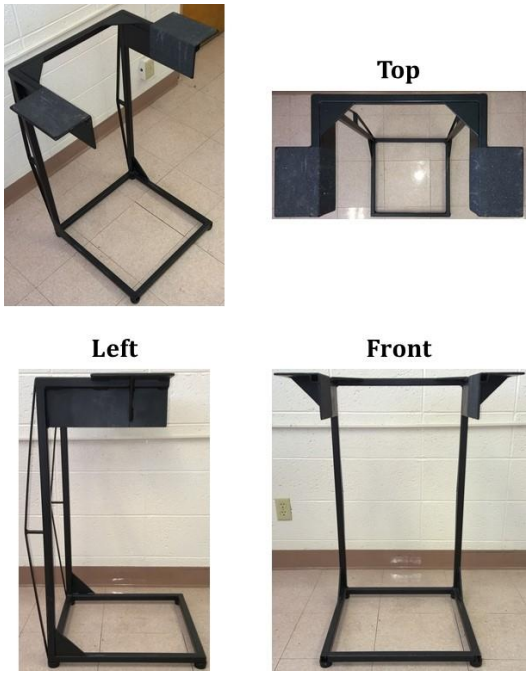


Figure 5: Different views of the test rig.

The testing rig is a frame made of 1 inch square steel tubing that stands $34\frac{5}{8}$ inches tall. The top of the frame consists of two arms, each with a 4x8 inch steel top plate and 4x13 inch steel side plate welded to top outside and bottom inside of the arms, respectively, see fig. 5. The arm and plate assemblies act as abutments and have adhesive sandpaper attached to them to help keep bridges from moving while loading. The nominal abutment separation distance with sandpaper is $17\frac{15}{16}$ inches.

Loading Hanger

Figure 6: The steel plate and hanger bolt that make up the loading hanger assembly.

The loading hanger consists of a steel plate with a $\frac{3}{8}$ inch hole drilled through its center, see fig. 6. Welded to the top of the plate and in-line with the hole is a washer and nut that a hook bolt is screwed into.

a) b)

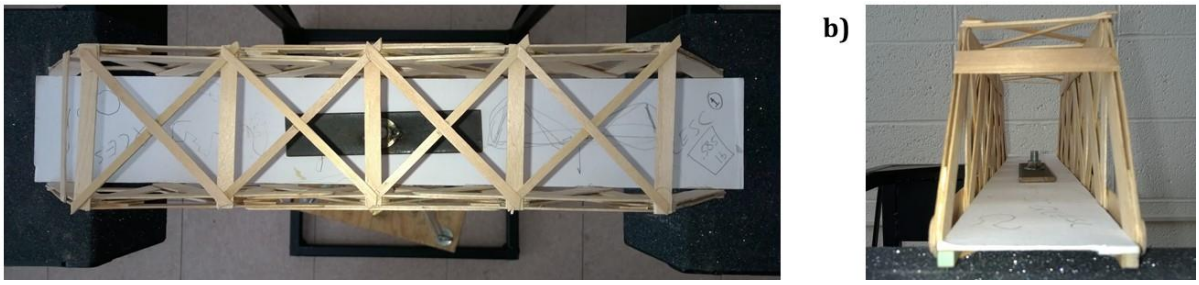


Figure 7: a) A top view of the load hanger attached to a bridge. b) A view down the span of a bridge with the load hanger attached.

The loading hanger is attached to the bridge by placing the steel plate flat on top of the deck with the nut facing up. The nut hole is placed in-line with that of the road deck poster board hole, see fig. 7. The hanger bolt is then fed through the road deck hole from the bottom and screwed into the nut.

Loading Platform

Figure 8: The loading platform.

The loading platform is used to support the load weight. It consists of two rectangular pieces of $\frac{3}{4}$ inch plywood fixed to one another by four eyebolts at the corners, see fig. 8. Each eyebolt has a $\frac{1}{4}$ inch braided nylon rope looped through it and fastened together at a steel hoop ring that hangs from the loading hanger.

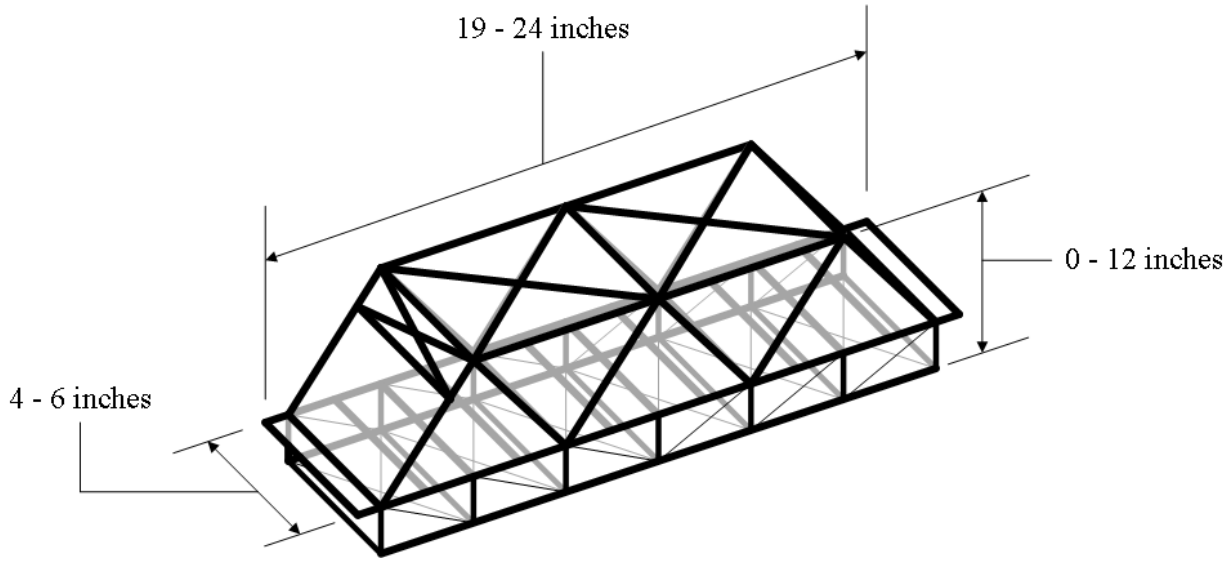
Loading Weights

Figure 9: The loading weights.

The loading weights are used to apply a load to a bridge and are placed on the loading platform when hanging from the loading hanger. Two sized steel weights are used, a gold painted 2 lb weight and a black painted 5 lb weight, see fig. 9.

Figure 10: A bridge spanning the two test rig abutments with the loading equipment attached and carrying 2 lb and 5 lb weights.

Bridge Inspection Checklist



Criteria	Acceptable
Bridge Length: 19 – 24 inches	
Bridge Height: ≤ 9 inches above deck ≤ 9 inches below deck ≤ 12 inches total	
Bridge Width: 4 inches min 6 inches max	
Decking across the entire length of the bridge span	
Deck capable of supporting weighted truck toy	
Assembly area clean/Tools and materials turned in	

Idea Generating Guidelines

1. Read this document thoroughly and watch the video at the listed link.

   (2012) http://www.youtube.com/watch?v=gMgBjHBjcfo&feature=youtu.be

   (2013 time lapse) http://www.youtube.com/watch?v=odFWmp6Sio4

2. Explore the internet for bridge building tips and other bridge building competitions.

   - The Bridge Site - http://www.bridgesite.com/funand.htm
   - Model Bridge Design - http://www.garrettsbridges.com/category/popsicle-bridges/
   - Independent Modeling Instructions - http://www.instructables.com/id/Popsicle-Stick-Bridge/
   - Independent Modeling Instructions - http://andrew.triumf.ca/andrew/popsicle-bridge/
   - West Point Bridge Designer 2012 - http://bridgecontest.usma.edu/download.htm

3. See pages 5-6 for bridge building basics provided by the American Society of Civil Engineers (ASCE).

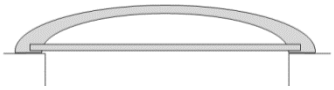
4. Observe real bridges while traveling.

Modeling Tips

1. Remember, for a real bridge, the important part is the steel and/or concrete structure that supports the deck the cars drive on not the deck itself.
2. A bridge needs to have a solid, stiff shape along its height, length and width. Meaning the structure should not bend or twist when weight is place on it. For example, a Popsicle stick is easier to bend along its flat side than along it edge.
3. A bunch of sticks glued together flat, like a raft, have very little strength and will sag during testing under very little load (a weight placed on it).
4. String as a structural member should always be in tension, in other words it should always be stretched.
5. The strongest structural shape is the triangle. A bridge made of a series of triangles will be very strong, see page 5.
6. A bridge that is symmetrical is less likely to twist when loaded and will probably carry more weight.
7. A bridge built too tall will have a high moment of inertia, increasing stiffness and strength (a good thing). However, it may become unstable and topple when under a load (a bad thing).
8. Care should be taken in the deck design to reinforce both the area where the loading plate rests and the ends where the bridge rests on the test stand with bracing.

Bridge Types

Tied Arch

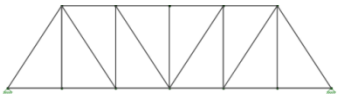


Arch

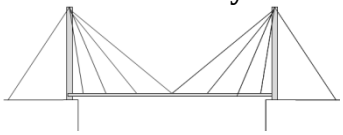
Basket Handle Arch

Suspension

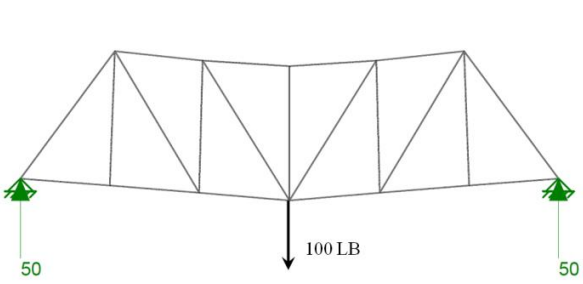
Truss

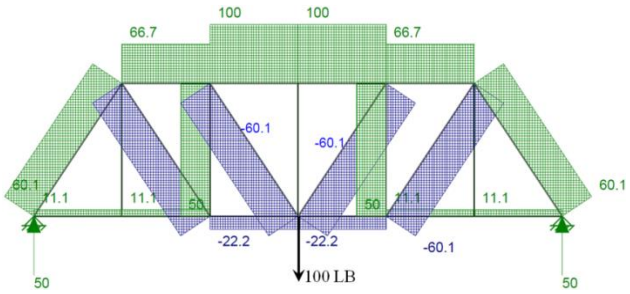


Cable Stay



Load Path

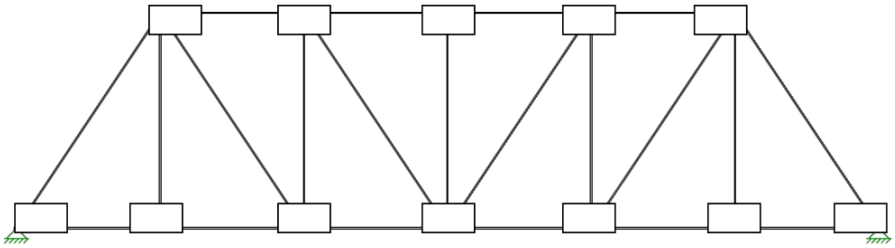




Compression members shown in green
Tension members shown in purple

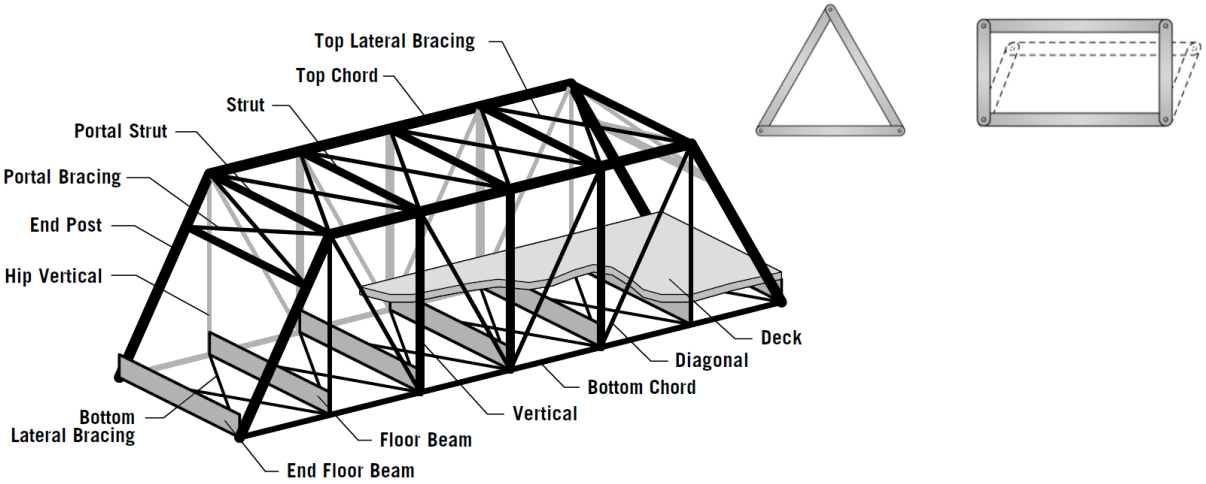
- Strengthen areas where loads are connected.

Connections



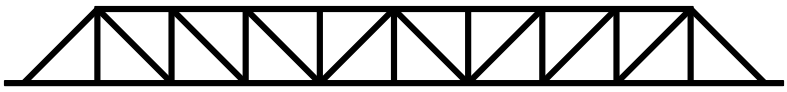
- Reinforce joints because bridges are only as strong as their connections.

Stability

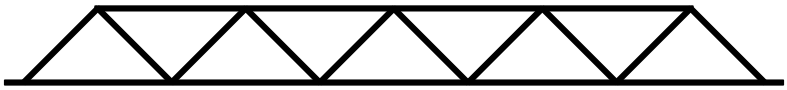


- Use triangular shapes to prevent rectangles from leaning/deforming.
- Members in compression such as the Top Chord will tend to buckle sideways during loading and buckling can be prevented by using Top Lateral Bracing.
- Some bridges will twist along their length during loading. Twisting can be prevented by using a "closed" shape such as a box or triangle as opposed to an "open" U-shape.

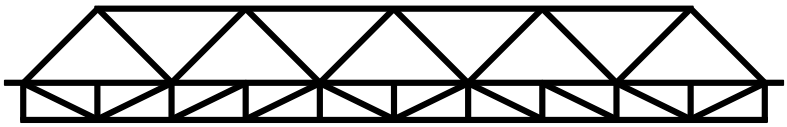
Truss Types



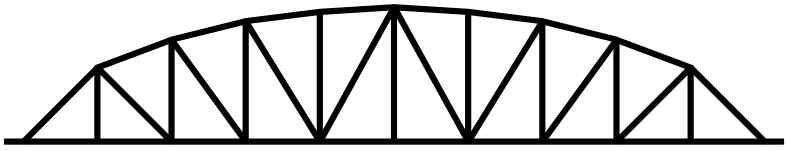
Pratt



Warren



Warren with Inverted Pratt



Camelback