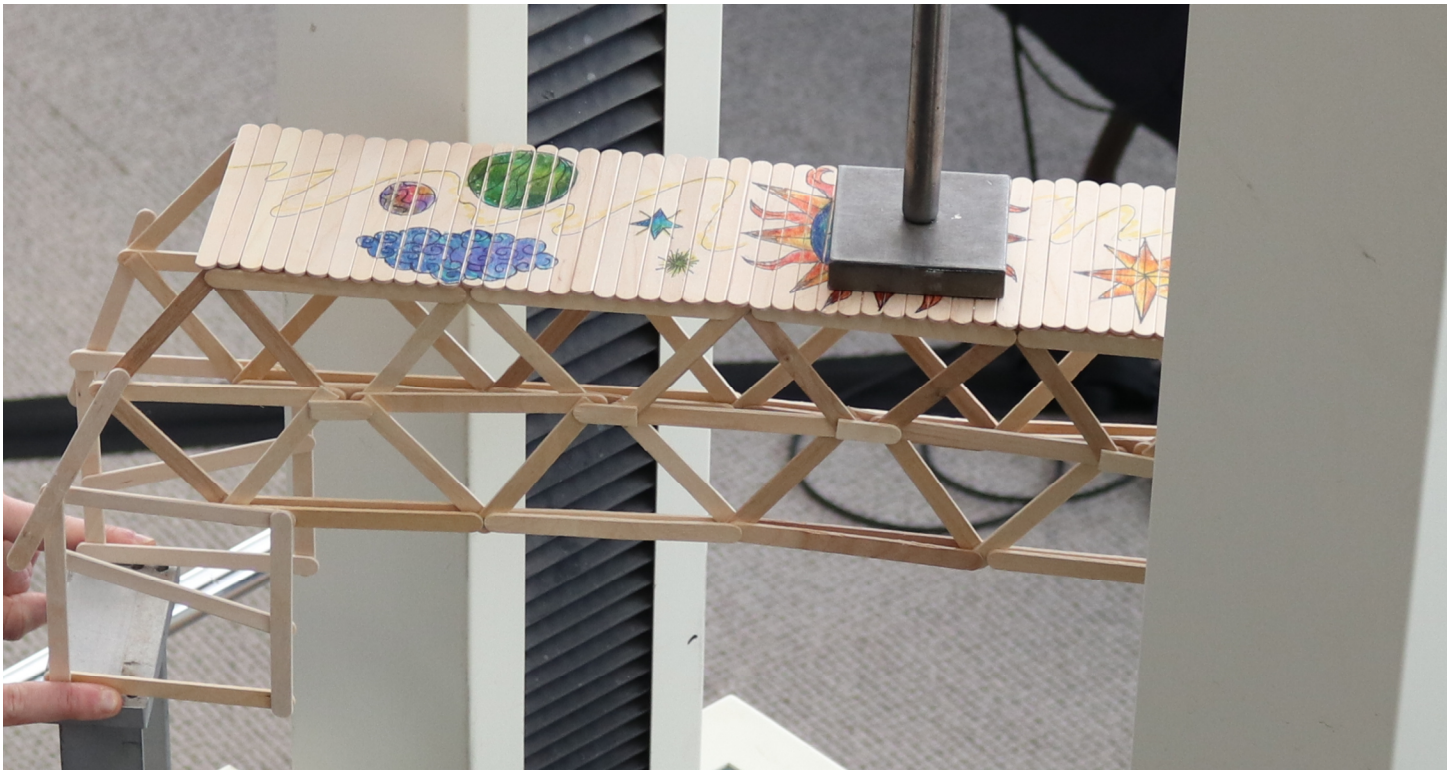
29th ANNUAL COMPETITION



2024 POPSICLE STICK BRIDGE COMPETITION

OFFICIAL RULES AND BUILDING CODE

ASCE
SEATTLE SECTION
YOUNGER MEMBER FORUM

The 2024 Popsicle Stick Bridge Competition will be

MARCH 16th, 2024

at the

MUSEUM OF FLIGHT

9404 East Marginal Way South
Seattle, Washington 98108

Contact Information:

museumofflight.org

206.764.5720

Exit 158 from I-5, head west, turn right at East Marginal Way,
the Museum of Flight is one-half mile on the right.

Popsicle Stick Bridge Organizing Chairs:

psb@seattleasce.org

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SECTION 1 – INTRODUCTION

1.1 Background

Bridges have fascinated people since the dawn of time when nature itself built many bridges in the form of fallen trees over rivers. As technology developed, people began to build artificial bridges where nature had not. Advances in bridge design, engineering, and construction have made many types of bridges using various materials possible.

Today, bridges can be of the arch, beam action, cable stay, suspension, truss, among others. Materials used throughout history include timber, masonry, cast iron, wrought iron, concrete, steel, reinforced concrete, alloy and silicon steel, pre-stressed concrete, carbon fiber, and aluminum.

Figure 1.1: An Under Bridge Inspection Truck at a timber and steel bridge in King County, Washington.

1.2 The Competition

The Seattle civil engineering community has hosted an annual Popsicle Stick Bridge Competition for 28 years. Individuals and teams from various schools build bridges using only popsicle sticks and white glue. Bridges are loaded until collapse. In the past, bridges weighing between 200 and 400 grams have carried loads ranging from a hundred pounds to over a ton!

Section 3 of this packet defines the rules to be used to construct bridges for the contest. These rules create a fair competition and ensure the bridges can be loaded with the equipment ASCE provides. Section 5 explains how the results of the bridge loading will be used to award prizes. Although the goal of the contest is to expose students to engineering practice, prizes promote creativity, extra effort, and make the contest more exciting for all involved.

1.3 Why Popsicle Sticks?

Popsicle sticks are imperfect. Some may be bent, warped, or knotty; while others may be brittle, thin, or cracked. Visual inspection will weed out grossly deformed sticks, but students must deal with the slight imperfections present in all sticks. This is true in the real world where perfect materials are not available and careful thought must be given to the reliability of the construction materials. Engineers must attempt to quantify and account for deficiencies in both initial and post-construction material properties during the design process.

Popsicle sticks are limited to a standard size that falls short of the overall bridge dimensions. In order to span a distance of **24-inches**, several sticks must somehow be connected together in a straight line. Again, this reflects real design problems where materials are finite in dimension and must be assembled in some manner to meet the engineer's needs.

By being limited to only two allowable materials - **wood popsicle sticks and white glue** - students will need to use creativity, ingenuity, and resourcefulness in order to maximize the strengths and minimize the inherent shortcomings of each material.

Teams are allowed and encouraged to decorate their bridge using: **markers, crayons and colored pencils only. NO paint or other adhesive materials are allowed.**

SECTION 2 – DEFINITIONS

AMERICAN SOCIETY OF CIVIL ENGINEERS is an organization that supports and encourages the advancement of science and the profession of civil engineering, the development of codes and standards, and the enhancement of human welfare through the actions of its members.

BRIDGE is a structure made of glued popsicle sticks that spans between supports. Every aspect of a bridge must fully comply with Section 3 of this Building Code in order to qualify for the competition. Section 3 is not a set of suggestions, but rather a set of requirements. In contrast, Section 4 has useful tips and suggestions, which you may or may not refer to.

CLEAR SPAN is the 'clear' distance between supports that the bridge must span across.

DECK is the surface of the bridge. It provides a smooth surface to walk, bicycle or drive on. It must be durable to withstand the exposure to the elements and traffic and the environment.

DISQUALIFICATION will prevent eligibility for prizes and you will not receive a score. This will occur when the rules of Section 3 are not followed after two opportunities to fix bridges at the competition.

DOWEL is a peg of wood for holding together components of a structure.

MEMBER is a portion of the bridge, whether made of a single stick, or multiple sticks, that connects two parts of the bridge together. The sticks in a member are generally oriented lengthwise between connections and the member is much longer than it is wide. For example, a beam is a member.

PIERS are portions of the structure that support the bridge and connect it to the ground. Most bridges will have at least two piers, with long ones having many more. Piers breakup the entire bridge length into smaller spans. In our competition, we will provide the piers as part of the testing apparatus. See Figure 3.2 for a diagram.

ROADWAY is the portion of the bridge that wheeled traffic would travel over. It is constructed by laying sticks flat edge-to-edge to create a large surface. Only the sticks that would actually come in contact with wheeled traffic are considered part of the roadway.

STACK is multiple sticks glued face-to-face. Stacks are made of at least two sticks and have no maximum number.

STICK is a single Popsicle stick. The broad side of a stick is called a FACE. There are two faces. The rest of the stick is narrow and is referred to as the EDGE of the stick.

STUDENT is described as any participant of a team that is currently enrolled in a high school-level math or science class. All members of a team must qualify as students.

TEAM is a group of up to four students (maximum) that compete in the competition. Any number of official teams are allowed to compete per school. A student can compete on one team only, and at least one student team-member must be present at the contest.

ULTIMATE CAPACITY is the maximum load that an element or structure can withstand at failure.

TIP FROM A CIVIL ENGINEER:

If you have competed in the past, you will notice that the 2024 Building Code has been modified from previous versions. To quickly see what has changed, look for the RED bar on the sides of pages that indicate new or different information.

SECTION 3 – 2024 BUILDING CODE

3.1 Materials

a. The Popsicle sticks shall be made of wood and have the approximate dimensions as in Figure 3.1. Teams may acquire their own Popsicle sticks or request sticks from the ASCE Younger Member Forum. *The use of any Popsicle sticks made of any other material or of other size will result in disqualification.*

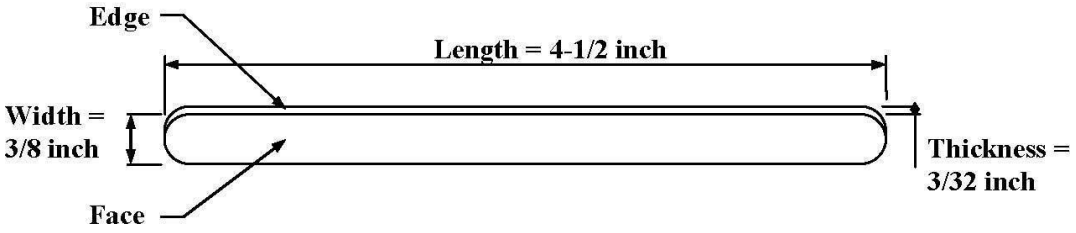


Figure 3.1 Example of a standard popsicle stick

b. Sticks may be physically altered in the following ways:
   i. Cut / notched at any angle.
   ii. Sanded to any width.
   iii. Bent or curved (sticks may be soaked in water ONLY to curve).
   iv. Marked on the face for decoration using only markers, crayons and/or colored pencils.

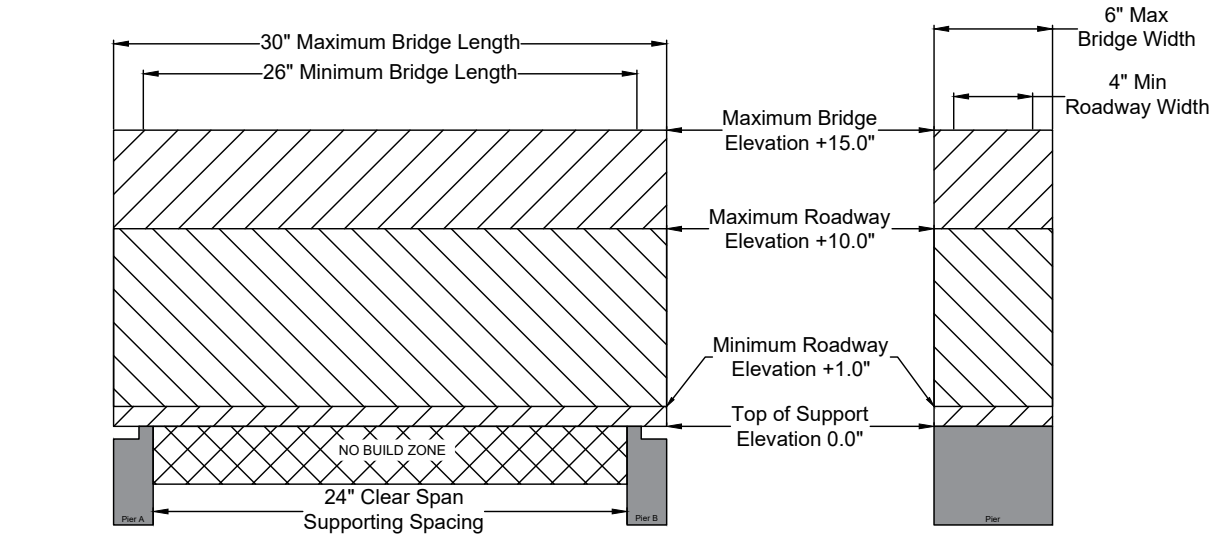
c. Sticks shall **NOT** be altered in following ways:
   i. Soaked in any material besides water.
   ii. Painted or coated except with markers, crayons or colored pencils on the face for decoration only.

d. ONLY water soluble white Elmer's glue shall be used as an adhesive.

Note:
Yellow wood-glue, glues containing resin adhesives, or other cement binders are **NOT** allowed.

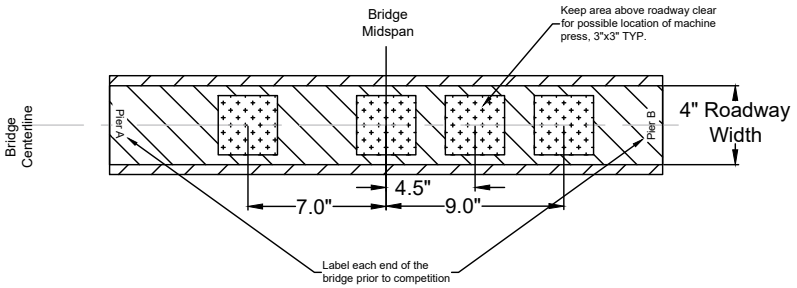
3.2 Overall Dimensions

a. The height of the bridge shall be less than or equal to **15-inches** measured from the bottom elevation (lowest point) of the structure to the top elevation (highest point) of the bridge. See Figure 3.2.
b. Structures above the roadway are allowed but must keep space for a vehicle to cross the bridge and loading at the positions designated in Figure 3.2. The Roadway deck shall be between **1-inch** and **10-inches** from the top of the piers.
c. The total bridge width shall be between **4-inches** and **6-inches** wide.
d. The bridge's **overall** length shall be greater than or equal to **26-inches** but shall not exceed **30-inches**. See Figure 3.2.
e. The clear span between the provided supports will be **24 ± ½ - inches**. See Figure 3.2.
f. No part of the bridge shall be within the No Build Zone. See Figure 3.2



DETAIL 1 - PROFILE VIEW

DETAIL 2 - END VIEW



DETAIL 3 - PLAN VIEW

NOTES:

- Roadway must be flat and continuous
- Roadway must be able to support up to 2250 grams with fewer than 0.5" deflection at any end
- Bridge must allow press access and pier sides must be labeled prior to competition.

ASCE SEATTLE SECTION YOUNGER MEMBER FORUM	ASCE YOUNGER MEMBER FORUM - SEATTLE	DATE: 11-04-2023
	2024 POPSICLE STICK BRIDGE COMPETITION	SCALE: NOT TO SCALE
	GENERAL BRIDGE SCHEMATICS	SHEET: 1 OF 1
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Figure 3.2: General Bridge Schematics

SECTION 3 – 2024 BUILDING CODE

3.3 Weight

Your bridge shall weigh a maximum of **325 grams** as measured on competition day.

3.4 Roadway

a. A 3-inch high by 3-inch wide vehicle must be able to pass the entire length of the bridge.
b. The roadway shall be continuous with no gaps (natural warping okay). The minimum dimensions of the roadway are: (minimum bridge length [26-inches]) X (4-inches). See Figure 3.2.
c. The roadway shall be flat and continuous width along its full length. It shall maintain a singular elevation within a 0.25" tolerance.
d. The entire roadway must be able to support a rolling vehicle weighing up to 2250 grams (about 5 pounds) with less than a half inch deflection (0.5"). This will be tested during the Technical Judging by using a stationary weight placed at strategic points across the bridge.

TIP FROM A CIVIL ENGINEER:

You can test out provision 3.4.d at home to get an idea if you need to strengthen any portions of your roadway. A standard block of butter weighs 1 pound, and a full 1 liter water bottle weighs about 2 pounds

3.5 Loading

The bridges will be loaded to failure during the competition. Bridges will be load tested to determine their ultimate load capacity.

a. The machine will apply a vertical load on top of the bridge, directly to the roadway, defined in Section 2. The roadway shall be supported by your bridge's structure. The structure of your bridge should be optimized, to the best of your ability, to support as much load as possible within the rules of the Competition Building Code.
b. The location of the load will be determined on the day of competition and will be at one of the four indicated areas in Figure 3.2. *The loading location will be the same for all bridges in the competition.*
c. The load will be applied directly to the roadway.
d. The machine press is **3-inches** by **3-inches.** Ensure there is a clear space above the possible locations of the machine press to allow load application to the roadway. See Figure 3.2 for a plan view (top view) of the bridge, including the areas to keep clear for possible locations of the machine press. **Using a permanent marker, label your bridge with 'Pier A' on the road at one end of the bridge, and with 'Pier B' on the road at the other end prior to arriving at the competition site.** If there are no marks, then a judge will determine the locations of Pier A and Pier B for you.

3.6 Supports

a. Supports (piers) will be provided for the bridge to sit on.
b. The provided supports will be placed 24 inches apart (clear span). See Figure 3.2.
c. The bridge shall not be constructed to exert any horizontal loads on the provided supports, other than friction at the top surface. The bridge shall not be within the bridge abutment no-build zone, as shown in Figure 3.2.

3.7 Construction

a. At least one entire side of the longest dimension (typically the edge or face) of each Popsicle stick used must be visible for judging. Figure 3.3 illustrates appropriate ways to combine sticks; these examples demonstrate that the longest dimension of each stick used, in each stack, is visually accessible. Figure 3.4 illustrates inappropriate ways to combine sticks; these examples demonstrate that the longest dimension of each stick used, in each stack, is not accessible visually because some edges or faces are in a void.
b. Only the end of a member needs to be seen for judging if it is being used as a dowel (See Section 2: Definitions).

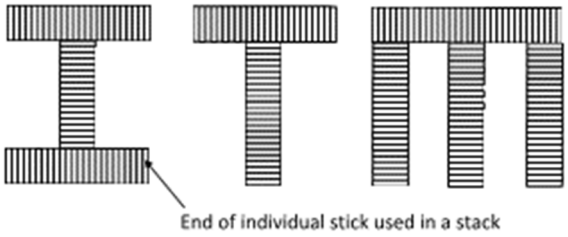

Figure 3.3: End view of members built in accordance to the 2024 Official Rules and Building Code

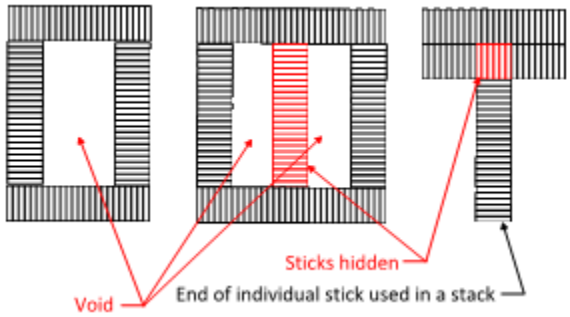

Figure 3.4: End view of members with voids and hidden sticks.

SECTION 4 – SUGGESTIONS FOR BRIDGE CONSTRUCTION

Remember, judges will be making sure you followed all of the rules according to Section 3 of this document. If you do not follow the rules in Section 3, your team will be disqualified. Make sure you have read and understood the rules before building your bridge. If you still have questions, have your teacher email our contest organizer or the classroom speaker.

Start with paper and pencil first. Sketch out your ideas. Draw your bridge in at least three views - looking at it from the side, looking at it from the end, and looking at it from the top so you get a good idea of what you're building.

Choose a design you are sure you can build. Think about how you will meet all the rules.

Plan Ahead. Glue takes time to reach its maximum strength. Build your bridge with time for the glue to dry and cure.

Sort through your popsicle sticks to find the best pieces. There is natural variation in materials like wood, think about how you can use this variation. Where would you want to put sticks that are slightly thinner?

Think about how the load will transfer from the loading area, through beams or trusses and out to the supports at each end of the bridge. Not all parts of your bridge will have the same forces running through them. What bridge members do you think will take the greatest load? Make those members stronger.

Which members do you think will be in compression? Which ones will be in tension? A single popsicle stick in tension can hold more weight than one in compression. Members in compression tend to buckle sideways. Make sure your compression members are strong and well braced against buckling.

Your bridge members are only as strong as your connections, so pay special attention to the connections! How can you construct strong connections? Make sure the gluing surfaces are large and flat. Use clamps to hold joints under pressure until the glue is dry.

If your bridge has similar patterns that are repeated throughout your design, construct modules or jigs so the pattern is accurately constructed each time. If your pattern is not dimensionally consistent or each side of your overall bridge is not symmetrical, some parts of your bridge will take more load than you originally planned.

If you use several rows of sticks to make up a structure, don't leave any sticks out of the structure or it probably will fail at that point.

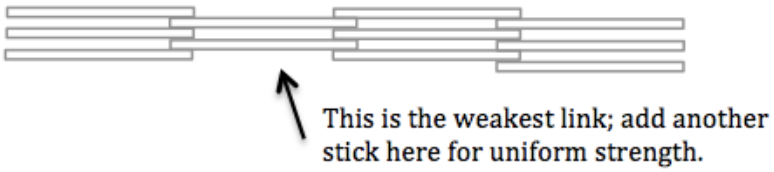

Figure 4.1: What is the weakest link of your bridge?

Before you build your entire bridge you may want to test small parts of your bridge and compare one design to another to see which is stronger. You can even test your stick connections.

SECTION 4 – SUGGESTIONS FOR BRIDGE CONSTRUCTION

Your bridge is loaded on a 3-inch by 3-inch square on the roadway. Consider adding sticks that will stiffen the roadway from the underside, and be sure to make strong connections between the roadway and the main members spanning the 24-inch gap of the provided supports. You don't want your roadway to fail before your main members are loaded up.

Lateral supports (members that are perpendicular to the direction of traffic on the bridge) are important to brace the tops of truss-type bridges, but the majority of the strength is needed in the main members spanning the 24-inch gap (members that are parallel to the direction of bridge traffic).

Remember – your bridge will be picked up and inspected during judging and will probably be turned upside down. Your bridge will also need to withstand transportation to the competition. Make sure that all your pieces are glued together and that your bridge will not fall apart or lose its shape.

If you design a truss, be sure it extends all the way to the ends where it will be supported. Don't put a truss just in the center portion of the bridge.

Figure 4.2: Think about where the load is applied, and how it will be transferred through your structure.

How does your bridge look? If this were a real bridge, do you think the public would find it pleasing to the eye? Can you make your bridge attractive and strong at the same time?

Construct a bridge on a surface that glue will not stick to! Try to work in an area you don't mind getting messed up, and always follow the instructions on the glue bottle.

Need some ideas to get the creative gears working? You can view photos and results from previous contests here:

https://www.seattleasceymf.org/psb. Keep in mind that the rules are different each year.

You may have enough time at the competition to make adjustments if your bridge does not qualify. Bring some tools just in case.

Tools to help you with your bridge construction:

a. Pencil
b. Paper
c. Wire cutters for cutting sticks
d. Exacto Knife
e. Hair dryer (to dry the glue quicker)
f. Clips, rubber bands, and weights to clamp pieces together when the glue is drying
g. PATIENCE!!! Good bridges take time to build.

SECTION 5 – JUDGING AND SCORING

5.1 Technical Judging

A panel of technical judges will review the bridges for any rule violations of Section 3. Any bridge with violations will be disqualified. However, if a rules violation can be corrected, the technical judges will allow the bridge to be modified, provided it can be requalified before the end of the competition registration.

If teams did not pass first judging, they will have two opportunities to fix their bridge. There will be some tools available to use, however, it is suggested for each team to bring some tools in the case their bridge does not comply with all rules. See Section 4 for suggested tools.

If, after two opportunities, the bridge still does not meet the rules listed in Section 3, the bridge will not be eligible for prizes.

The decisions made by the technical judges are final. No challenges, appeals, or complaints will be heard. After the technical judging, a panel of aesthetic judges will evaluate the bridges.

5.2 Scoring

Bridges will be evaluated and scored in three categories: efficiency, aesthetics, and the accuracy of your estimated load. These categories are described below and will be combined to create an overall score.

5.2.1 Aesthetic Judging

Your bridge will be scored on **aesthetics**. Professional designers will judge your bridges based on the level of detail of the connections and members, the uniqueness of your design and its overall look. Judges will score each bridge between 4 and 40, based on: (1) detail to connections, (2) detail to members, (3) uniqueness of design, and (4) overall appearance. The final Aesthetics score will be the average score from the judges. Many bridges are paid for by the public, and if people don't like using it or looking at it, they will be unhappy paying for it! So before constructing your bridge take some time to think about how you want it to look in the end.

5.2.2 Efficiency

Your bridge will be scored on how well you have used your materials to support the load. We call this **efficiency** and define it as the ratio of ultimate load capacity to bridge weight. In engineering, the best solution may not always be the biggest or strongest bridge. Typically our designs are driven by limitations such as money or availability of resources. These constraints often push us to find a solution that satisfies these limitations most efficiently.

The efficiency score will be calculated by dividing the load your bridge is able to carry by the weight of the bridge. Because of this, the most efficient bridge might not be the one that carries the most load. As an example, if your bridge is able to carry a 5 lb load and weighs the maximum amount allowed in the competition, 325 grams (~0.72 lb), your efficiency would be 6.98. For calculating the overall score, the efficiency ratio will be normalized to a 40 point scale.

5.2.3 Estimation

Your bridge will also be scored on how well you have estimated the load your bridge can support. We call this **estimation** and define it as the ratio of the load estimate to the ultimate load capacity. A ratio closest to 1 will benefit your score; all ratios will be scored by their proximity to 1, which represents a perfect guess. Teams are to provide a load estimate on their score sheet prior to breaking their bridge. For the overall score, the Estimation score will be translated to a 40 point scale, so a perfect estimate (ratio = 1.0) will receive 40 points overall.

In this competition, your bridge will be loaded to its ultimate capacity. Once this load is reached, the bridge will break such that it can no longer hold the same maximum capacity again. The ultimate load capacity of each bridge is needed to determine its efficiency. Most often your bridge will be damaged beyond repair. Sometimes bridges will shatter into pieces or be broken in half. It makes the contest very fun to watch! As you develop your estimate for your bridge's ultimate capacity, consider the strength of the weakest link in the structure. This will control the strength of the entire design.

5.2.4 Overall Score

The overall score will come from adding up each component score for a maximum score of 120 points. Each of the categories will be weighted equally for the overall score.

5.3 Prizes

Prizes in the past have included, bluetooth speakers, Hydro Flasks, Yeti tumblers, gift cards, and much more. Prizes are awarded to each person in the winning teams.

Complete prize packages are given to the top THREE TEAMS in the following category:

- Overall

Smaller prizes are given to top preforming teams in the following categories:

- Strongest Bridge
- Most Aesthetically Pleasing Bridge
- Most Efficient Bridge

Small prizes are also given to the top ONE TEAM in the following categories:

- Teamwork
- Most Accurate Estimate

We will also award a prize to ONE PERSON for the T-shirt competition; more information is included in Section 6.

SECTION 6 – T-SHIRT COMPETITION

In the real world, many engineers spend time doing non-technical tasks in addition to design work, such as pursuing new projects, public outreach, and more. The T-Shirt competition is a way to explore your creative side while working on a technical engineering project. The ASCE Younger Members Forum has every intention of using the winner's design for the following year's Popsicle Stick Bridge T-Shirts. With this in mind, the following rules have been established for creating your T-Shirt entries and for judging them.

6.1 General

a. Each person may submit one T-Shirt design for the competition.
b. All designs shall be your own, avoid copyrighted material.
c. All designs must be appropriate for reproduction and public display.
    i. No vulgar language
    ii. No vulgar use of graphics
d. Submit a design via email to psb@seattleasce.org by the day of competition or by bringing a print out to the competition.

6.2 Specifications

a. The T-Shirt shall have "ASCE", "30th Annual Popsicle Stick Bridge Competition", and "2025" on it and in some way display a graphic of a bridge.
b. The T-shirt design will be for the front of the shirt.
c. Be creative!

6.3 Judging

A panel of Popsicle Stick Bridge Competition volunteers will select the winning T-Shirt based on creativity of design and overall T-Shirt product. The judging panel will take into account the Specifications in Section 6.2 and the ease of production.

6.4 Prizes

a. Prizes will be awarded to the overall winner of the T-Shirt Competition.
b. The winning shirt may be used for the following year's Team Shirt.
    i. The ASCE-YMF holds the right to modify the winning T-Shirt design in both scale and content.
    ii. The ASCE-YMF will work with the winning T-shirt designer if any alterations must be made to use the T-Shirt Design.
    iii. Cost of production, ease of duplication, and other factors of economy are concerns governing the ASCE-YMF's alterations of the winning design.

6.5 Recommendations

a. T-Shirt concepts should be something you are willing to wear.
b. The T-shirts will be one solid color with one color of text so keep that in mind. You can recommend a color to go along with your design. (More colors = Greater cost of printing shirt)
c. Again, be creative!

SECTION 7 – FREQUENTLY ASKED QUESTIONS

CAN WE NOTCH THE MEMBERS?

Yes. See Rule 3.1.b.

CAN WE DRILL HOLES THROUGH THE MEMBERS OR CUT SLOTS IN THEM?

Yes. See Rule 3.1.b.

CAN WE SHAVE THE MEMBERS TO MAKE THEM THINNER OR NARROWER?

Yes. See Rule 3.1.b.

CAN WE SATURATE THE MEMBERS IN WHITE GLUE?

No., Rule 3.1.c restricts the soaking of the members to water. Water from your home's or school's tap is appropriate for soaking members in.

CAN WE COLOR THE BRIDGES OR ADD DECORATIONS TO THEM?

Yes, with markers, crayons and colored pencils only. See Rule 3.1.c.

CAN WE GLUE THE STICKS TOGETHER TO FORM A CORNER OR "L" SECTION?

Yes, just make sure each stick is visible for judging according to Section 3.7.

CAN WE STEAM THE STICKS?

Yes. Sticks may be steamed to form curved shapes allowed in Rule 3.1.b.

DOES THE 3" X 3" LOAD AREA IN RULE 3.5.C REQUIRE CLEAR ACCESS ABOVE IT FOR THE LOAD APPLICATION?

Yes. The bridges are loaded from above, directly onto the roadway defined in Section 3.5.

IF SOME PAPER WAS ACCIDENTALLY GLUED TO A MEMBER, WILL THAT COUNT AGAINST US?

Not if it was truly accidental and wasn't for aesthetic purposes.

DOES THE ROADWAY HAVE TO MEET THE SUPPORTS AT GRADE?

No. The roadway shall be above the supports.

WHAT IF A STUDENT HELPS BUILD MORE THAN ONE BRIDGE? IS THAT OKAY?

Yes. A student may help other teams and build other bridges, but they can only enter the competition on one team. Each student is responsible for only one bridge ultimately and every student has an equal chance of winning a prize.

HOW DO I DETERMINE THE NUMBERS OF STACKED STICKS IF I HAVE MEMBERS GLUED TO A JOINT AT MULTIPLE ANGLES?

There is no limit to the size of a stack, but avoid creating voids within stacks (Section 3.7).

CAN MIDDLE SCHOOL LEVEL STUDENTS PARTICIPATE IN THE COMPETITION?

Yes. Although the competition is targeted towards high school students, middle school students can participate in this competition and will be eligible to win prizes.