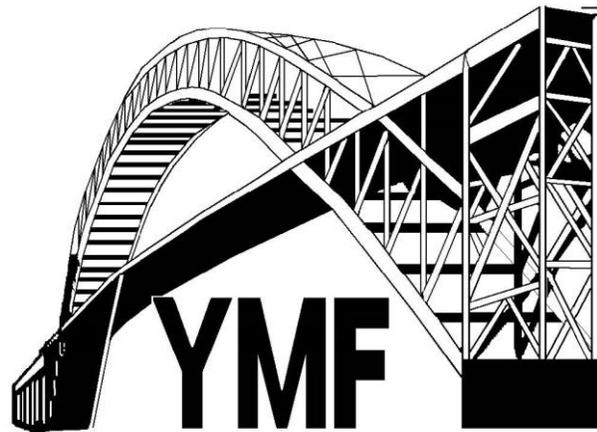




# 2019

## POPSICLE STICK BRIDGE COMPETITION BUILDING CODE



### Younger Member Forum

Email: [Seattle.ASCE.YMF@gmail.com](mailto:Seattle.ASCE.YMF@gmail.com)

[psbschooloutreachcoordinator@gmail.com](mailto:psbschooloutreachcoordinator@gmail.com)

Website: <http://seattleasce.org/y mf/popsiclebridge.html>

The 2019 Popsicle Stick Bridge Competition

is:

**February 9<sup>th</sup>, 2019**

The Competition is Intended to be Located at:

**The Museum of Flight**

<http://www.museumofflight.org>

9404 East Marginal Way South,

Seattle, WA 98108-4097

206.764.5720

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

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## SECTION 1 – DEFINITIONS

**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.

**DISQUALIFICATION** will prevent eligibility for prizes and you will not receive a score. This will only occur when the rules of Section 3 are not followed in their entirety.

**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.

**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.

**STRUCTURE** is described as any portion of the bridge, from the smallest single member to the entire bridge itself.

**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.

**SUPPORTS** are the end surfaces that will support the bridge.

**TEAM** is a group of up to four students (maximum) that compete in the competition. Three 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 competition. Additional unofficial teams are also welcome.

## SECTION 2 – INTRODUCTION

### 2.1 - Background

Bridges have fascinated people since the dawn of time when nature itself built many bridges in the form of fallen trees over rivers or ancient icicle arches. 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 possible and utilizing numerous materials.

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

### 2.2 - The Competition

One of the traditional competitions in the civil engineering community is the Popsicle Stick Bridge Competition. Individuals and teams from various schools build bridges using only Popsicle sticks and white glue as building materials. 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 competition. These rules are needed to create a fair competition and to 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 competition is to expose students to engineering practice, prizes promote creativity, extra effort, and make the competition more exciting for all involved.

### 2.3 - 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.

Popsicle sticks are limited to a standard size that falls short of the overall bridge dimensions. In order to span a distance of **26-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.

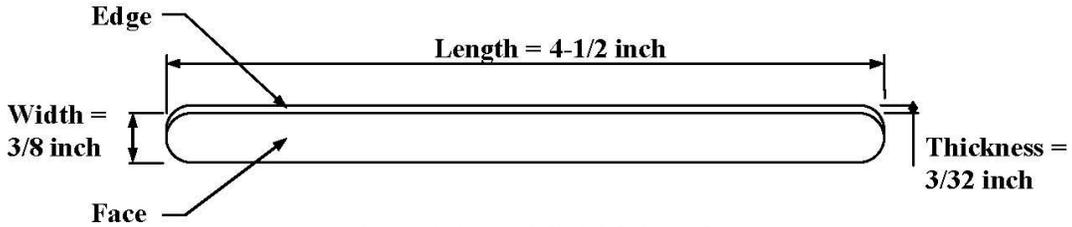
By being limited to only two allowable materials - **wood popsicle sticks and white glue** - students will need to use creativity, ingenuity, and resourcefulness in order to maximize the strengths and minimize the inherent shortcomings of each material.

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

**SECTION 3 – 2019 OFFICIAL BUILDING CODE**

3.1 – Materials

- a. The Popsicle sticks must 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 Popsicle Stick Sample**

- 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 may **NOT** be altered in the following ways:
- i. Soaked in any material besides water.
  - ii. Painted or coated except with markers, crayons or colored pencils on the stick for decoration only.
- d. ONLY water soluble white Elmer’s glue can be used as an adhesive.

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

3.2 – Overall Dimensions

- a. The height of the bridge must be less than or equal to **12-inches** measured from the bottom elevation (lowest point) of the bridge to the top elevation (highest point) of the bridge. See Figure 3.2.
- b. Structures over the roadway are allowed but must keep space for a vehicle to cross the bridge. The Roadway must be between **5-inches** and **8- inches** from the top of the piers.
- c. The total bridge width must be equal or between **4-inches** and **5-inches** wide.
- d. The bridge’s **overall** length shall be greater than or equal to **28-inches** but shall not exceed **30-inches**. See Figure 3.2.
- e. The clear span between the provided supports will be **26-inches**. See Figure 3.2.
- f. No part of the bridge shall be within the No Build Zone. See Figure 3.2.

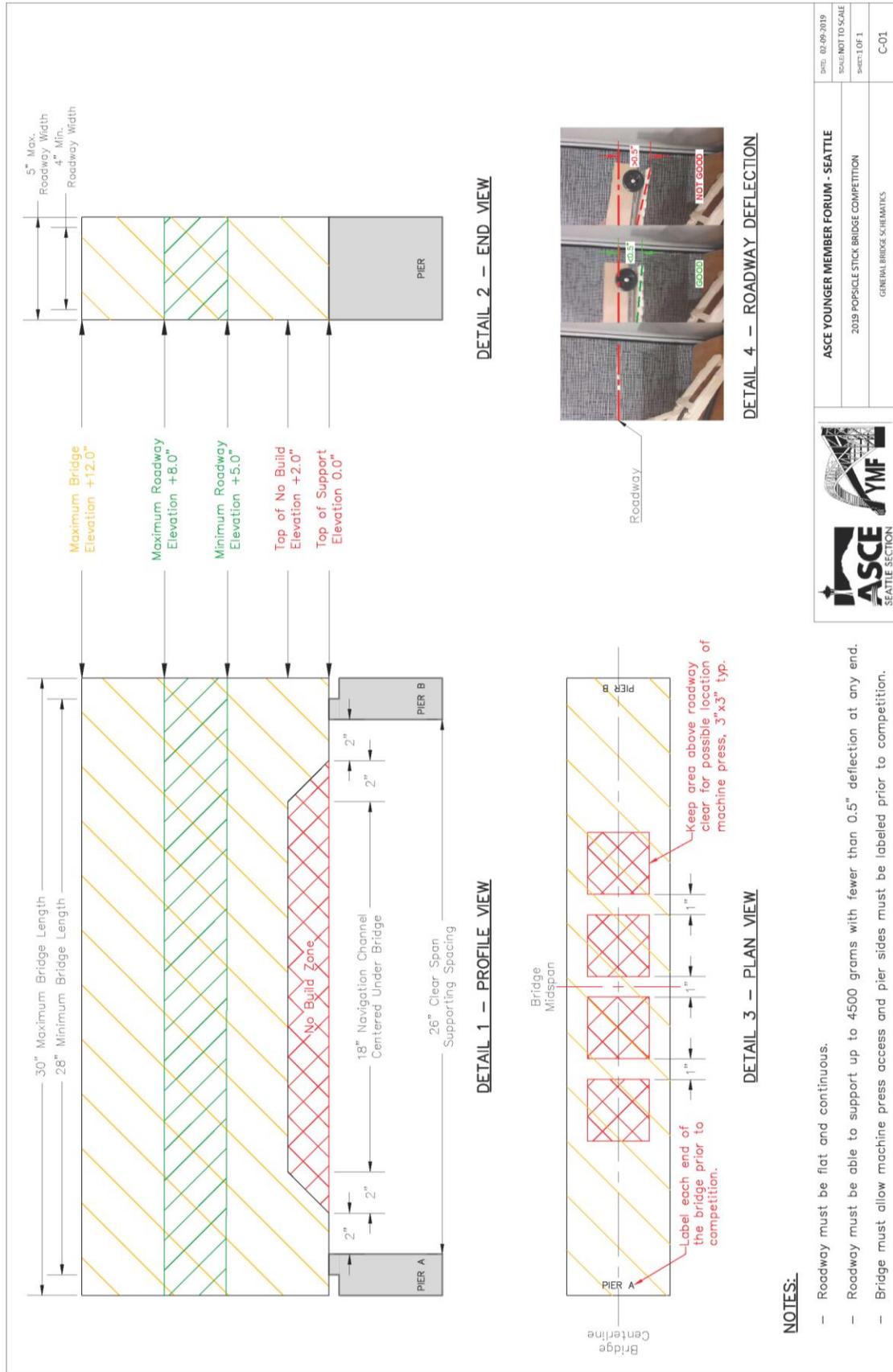


Figure 3.2: General Bridge Schematics

### 3.3 – Weight

- a. Your bridge must weigh **350 grams or less**.

### 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 must be continuous with no gaps (natural warping okay). The minimum dimensions of the roadway are: **(minimum bridge length [28 inches]) X (4-inches)**.
- c. The roadway must be flat and continuous width along its full length. It shall maintain same elevation with a **0.25"** tolerance.
- d. No part of the top of the roadway defined in **Section 1** can be greater than **8-inches** above or less than **5-inches** above the top of the end supports provided.
- e. The entire roadway must be able to support a rolling vehicle weighing up to 4500 grams (about 10 pounds) with less than a half inch deflection (**0.5"**). This will be tested during the Technical Judging by using a weighted pine wood derby car rolled across the bridge.

### 3.5 – Loading

The bridges will be loaded to ultimate capacity during the competition. Bridges will be broken in the determination of their ultimate load capacity.

- a. The machine will apply a vertical load on top of the bridge, directly to the roadway defined in **Section 1**. The roadway shall be supported by your bridge's structure. The structure of your bridge shall be optimized, to the best of your ability, to support as much load as possible within the rules of this section.
- 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.

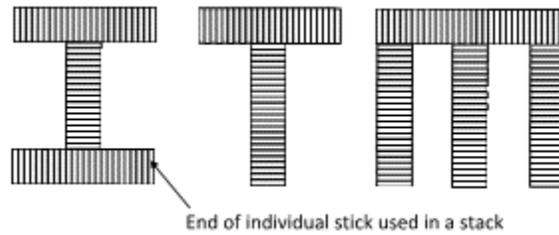
### 3.6 – Supports

- a. Supports will be provided for the bridge to sit on.
- b. The provided supports will be placed **26 inches** apart (clear span). See Figure 3.2.

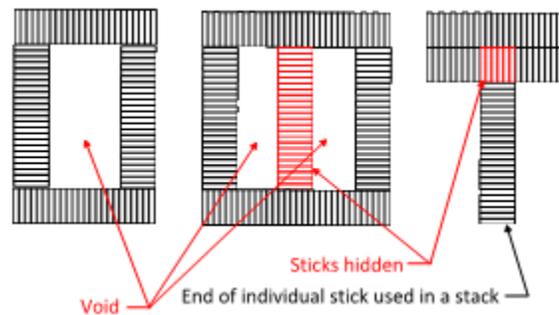
- c. The bridge shall not be constructed to exert any horizontal loads on the provided supports, other than friction at the top surface. The bridge shall not be within the bridge abutment no-build zone, as shown in Figure 3.2.

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 1**: Definitions).



**Figure 3.3: End View of Acceptably Combined Sticks**



**Figure 3.4: End View of Unacceptably Combined Sticks**

## SECTION 4 – TIPS FOR BRIDGE BUILDING

Remember, judges will be making sure you followed all the rules according to **Section 3** of this document. If you do not follow the rules in **Section 3**, you won't be able to win prizes. Make sure you have read and understood the rules before building your bridge. If you still have questions, have your teacher email our competition 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. Try using the Bridge Designer Software at <https://bridgecontest.org/> to get an understanding of how bridges transfer loads.

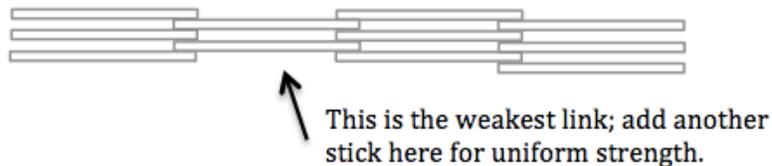
Think about how the load will transfer from the loading area, through beams or trusses and out to the supports at each end of the bridge. Not all parts of your bridge will have the same forces running through them. What bridge members do you think will take the greatest load? Make those members stronger.

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**

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.

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 26-inch gap of the provided supports. You don't want your roadway to fail before your main members are loaded up.

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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 most of the strength is needed in the main members spanning the 26-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. 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 section.



*Figure 4.2*

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.

Are you at a loss for ideas? You can view photos and results from previous competitions here: <http://www.seattleace.org/ymf/popsiclebridge.html>. Keep in mind that the rules are different each year.

Plan ahead!!! Don't wait until the night before the competition to finish the bridge! (Wet or damp glue doesn't work very well.) 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 – First 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 *may* allow the bridge to be modified, provided it can be re-qualified before the end of the competition registration.

After the technical judging, a panel of aesthetic judges will evaluate the bridges based on aesthetic, creativity, ingenuity, and personality.

### 5.2 – Challenges

Challenges may be made following the first judging period. Only students with bridges that have not been disqualified may challenge another bridge that they feel to be in violation of the rules.

Any bridge that has been disqualified during the first judging period may be appealed.

### 5.3 – Second Judging

The panel of technical judges will review all challenged bridges. In addition, the panel will review the bridge of any team that challenges another bridge. Be sure that your bridge meets the requirements of which you are judging another team for.

The technical judges will hear all appeals.

The decisions made by the technical judges after the second judging period are **final**. No challenges, appeals, or complaints will be heard after this time.

### 5.4 – Scoring

Bridges will be evaluated in three categories: efficiency, aesthetics, and the accuracy of your estimated load. These categories are described below.

Your bridge will be scored on how well you have used your materials to support the load. We will 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.

Your bridge will also be scored on aesthetics. Five professional designers will judge your bridges based on their detail to connections and members, and the uniqueness of your design. Bridges will be scored 1-10 by each professional, with the total lowest possible score been 5 and the total highest possible score been 50. All bridges must meet aesthetic criteria because they must function well with their environment. 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.

Your bridge will also be scored on how well you have estimated the load your bridge can support. We will 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 capped at 5. Teams are to provide a load estimate on their score sheet prior to breaking their bridge. A minimum actual load of 50 lbs. is required.

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In this competition, your bridge will be loaded to its ultimate capacity. After this load is reached, the bridge will break to an extent that it will never be able to hold as much load. 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 competition very fun to watch!

Each bridge will be scored against the others in each of the categories for an overall score. To ensure equal weight, the highest score for efficiency will be given 100 points. The lowest score will receive 50 points. All other scores will be weighted accordingly. The scores for each category will be input in the Total Score (T) Formula. The bridge with the highest overall score wins first prize. In the event of a tie for the overall rank, the bridge efficiency will be used as the tie-breaker, and the team with the highest efficiency score will be declared the winner. An example of overall ranking is illustrated in the table below.

	Bridge Weight ( $\omega$ )	Estimated Load ( $P_{est}$ )	Ultimate Load ( $P_u$ )	Efficiency Factor ( $e$ )	Efficiency Score ( $S_e$ )	Estimation Score ( $S_{est}$ )	Aesthetics Score ( $S_a$ )	Total Score (T)	Overall Rank
A	348	555	532	1.53	62	1.04	47	106.74	2
B	350	1000	2168	6.19	100	1.54	29	93.99	4
C	349	700	827	2.37	69	1.15	36	95.91	3
D	332	78	245	0.74	56	1.68	25	58.26	9
E	341	500	1	0.00	50	5.00	50	60.00	7
F	345	300	367	1.06	59	1.18	20	69.53	5
G	347	500	278	0.80	56	1.80	31	62.38	6
<b>H</b>	<b>339</b>	<b>1000</b>	<b>1256</b>	<b>3.71</b>	<b>80</b>	<b>1.20</b>	<b>50</b>	<b>116.37</b>	<b>1</b>
I	340	450	526	1.55	62	1.14	5	59.58	8

$$e = \frac{P_u}{\omega}$$

$$S_{est} = 1 + \left| \frac{P_u - P_{est}}{P_u} \right|$$

$$T = \frac{S_e}{S_{est}} + S_a$$

5.5 – Prizes

Complete prize packages will be provided for the top THREE overall winners. Prizes in the past have included Kindle Fires, graphing calculators, back packs, Mariners tickets, gift cards, and much more. Smaller prizes are given to the top three teams in the other categories, along with the teamwork award.

**CATEGORIES**

- Strongest Bridge*
- Most Aesthetically Pleasing Bridge*
- Most Efficient Bridge*
- Most Accurate Estimate*
- Teamwork Award*
- Overall*

## SECTION 6 – T-SHIRT COMPETITION

The T-Shirt competition is a new way to explore your creative side. The ASCE-YMF has every intention of using the winner’s design for the following year’s 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 team 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 or use of graphics.
- d. A sample T-Shirt with your design is preferable, but a print-out of your design on paper is acceptable.
- e. Have a digital copy of your design in PDF format ready to submit to the ASCE-YMF on the day of the event.

### 6.2 – Specifications

- a. The T-Shirt design shall have “ASCE”, “25<sup>th</sup> Annual Popsicle Stick Bridge Competition”, and “2020” 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. A panel of five 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 years 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 team 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 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, please be creative!

## SECTION 7 – FREQUENTLY ASKED QUESTIONS (FAQ’S)

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 (H<sub>2</sub>O). Water from your homes 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/or 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. Rule 3.4.d states that the roadway shall be no more than 8.0-inches or less than 5.0-inches above the end 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 with stacks (Section 3.7).*

Can middle school level students participate in the competition?

*Yes, but only at an unofficial level. No team that includes a middle school level student may be eligible for awards or prizes. If you have a middle school student enrolled in a high school level math and/or science course, please contact the PSB Committee at [seattle.ASCE.YMF@gmail.com](mailto:seattle.ASCE.YMF@gmail.com) for guidance on official rules.*