



GEORGE MASON UNIVERSITY
2009 POPSICLE STICK
BRIDGE BUILDING CONTEST



OFFICIAL RULES

(Based on the rules used by the Seattle ASCE YMF. Used with permission)

The Contest Will Be Held on:
February 19, 2009

at:
George Mason University

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Chapter 1 - INTRODUCTION

101 - BACKGROUND

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

Today, bridges can be of the span, arch, or suspension 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.

102 - THE CONTEST

One of the traditional competitions in the civil engineering community is the Popsicle Stick Bridge Contest. Individuals and teams from various schools build bridges using only Popsicle sticks and white glue as building materials. Bridges are loaded until the bridge collapses. In the past, bridges weighing between 200 and 400 grams have carried loads ranging from a hundred pounds to over a ton!

Chapter 2 of this packet will define the rules to be used to construct bridges for the contest. These rules are needed to create a fair competition and to ensure the bridges can be loaded with the equipment GMU provides. Section 104 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.

103 - 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 30 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.

104 - SCORING

Bridges will be evaluated in two categories: efficiency, and aesthetics. These two 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. Professional designers, who create real buildings and bridges as a career, will judge your bridge on style and construction. All bridges must meet aesthetic criteria because they must function well in their environment. A good looking bridge that is well constructed and easy to use will be used more often. People will want it to last. 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!

In this contest, 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 broken in half. It makes the contest very fun to watch!

Each bridge will be ranked against the others in each of the two categories for an overall score. Each category will have equal weight. For instance, the bridge with the highest efficiency will receive the rank of 1, or score 1 point. The bridge that has the second highest efficiency receives a rank of 2, or scores 2 points. In the event of a tie, both bridges will receive the same rank, and the following bridge will receive the next possible rank (i.e., if there is a two-way tie for third place, the next bridge would receive fifth place, or five points). The same ranking system will apply to the other category, and all points will be added together for an overall score. The bridge with the lowest overall score wins first prize. In the event of a tie for the overall rank, a third category, bridge weight will be used as a tie-breaker, and the team with the lightest bridge will be declared the winner. An example of overall ranking is illustrated in the table below.

Team	Bridge Weight	Actual Load	Efficiency	Efficiency Rank	Aesthetics Rank	Overall Score	OV R
A	348	532	1.5	5	1	6	
B	350	2168	6.2	1	7	8	
C	349	827	2.5	3	6	9	
D	332	245	0.7	8	3	11	
E	341	1	0.0	9	8	17	
F	345	367	1.1	6	2	8	
G	347	278	0.8	7	5	12	
H	339	1256	3.7	2	9	11	
I	340	526	1.5	4	4	8	2

In addition to the prizes for the overall competition, bonus prizes will also be awarded to the team whose bridge supports the highest load and the team that comes closest to estimating the load capacity of their bridge.

Below is an example of the two additional prize categories:

Highest Load:

Team	Actual Load	Load Rank
A	532	4
B	2168	1
C	827	3
D	245	8
E	1	9
F	367	6
G	278	7
H	1256	2
I	526	5

Best Estimated Load:

Team	Estimated Load	BELC %	BELC Rank
A	100	432%	9
B	2000	8.40%	2
C	500	65.40%	8
D	700	65%	7
E	2	50%	5
F	1000	63.33%	6
G	500	44.40%	4
H	1000	25.60%	3
I	500	6.40%	1

Best Estimated Load Capacity is calculated using the following formula:

$$BELC = [(Actual Load) - (Estimated Load)] / (Estimated Load) \times 100.$$

105 - PRIZES

The top three finishers of the overall competition will receive complete prize packages while the highest load and best estimated load will win smaller prizes. All students will receive a commemorative T-shirt and a certificate.

Chapter 2 - CONTEST RULES

SECTION 201 - SCOPE

This chapter prescribes general design requirements applicable to all Popsicle stick structures regulated by this code.

SECTION 202 - DEFINITIONS

- **BRIDGE** is a structure that is self-supporting between supports and complies with this code.
- **CLEAR SPAN** is the clear distance between the supports that the bridge must span over.
- **DISQUALIFICATION** will prevent eligibility for prizes and you will not receive a score. This will only occur when the rules of Chapter 2 are not followed in its entirety.
- **LAMINATED** is the actual portion of the face of a stick that is glued to another member.
- **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, but the roadway is not a member.
- **ROADWAY** is the portion of the bridge that wheeled traffic would drive over. Normally it is constructed by laying sticks flat and 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 at can be at most six sticks.
- **STICK** is a single Popsicle stick. The broad side of a stick is called a **FACE**. There are two faces. The rest of the sides of the stick are narrow and are called **EDGES**.
- **STUDENT** is described as any participant of a team that is currently enrolled in high school.
- **SUPPORTS** are the end surfaces that will support the bridge. The supports will have the dimensions of 3/4 inches wide by 5 inches long.
- **TEAM** is a group of up to three students (maximum) that compete in the competition. Four teams are allowed to compete per school. Each student must enter the competition on only one team, and at least one team member must be present at the contest.

SECTION 203 - DESIGN

203.1 Materials.

1. Use Popsicle sticks with the following dimensions (available at many craft and grocery stores):

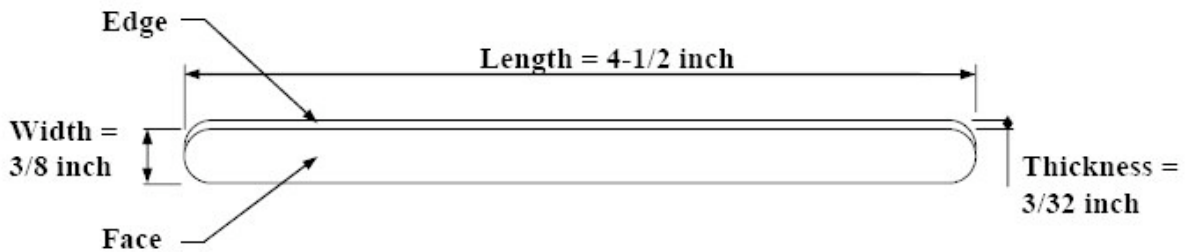


Figure 203.1

2. Sticks may not be altered or modified in any way, except for the following:
 - a. Sticks may be cut so that their length is less than 4-1/2 inches.
 - i. Cuts must be complete through the entire width and thickness (no notches).
 - ii. Cuts can be made perpendicular to the length or angled up to 45 degrees. See Figure 203.2.
 - b. Sticks may be sanded slightly to remove waxy film prior to gluing.
 - c. Sticks may be bent or curved.
3. Use water soluble white Elmer's glue.

NOTE: Yellow wood glue or glues containing resin additives or other cement binder is not allowed.

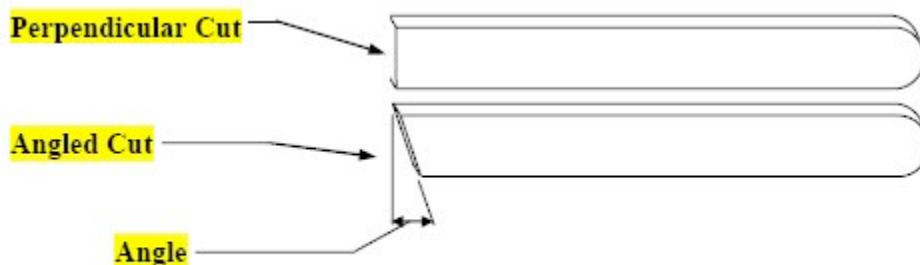


Figure 203.2

203.2 Overall Dimensions.

1. The bridge may not exceed 10 inches above the end supports and may not extend below the end supports.
2. The total bridge width must be 5 inches or less.
3. The bridge length must be between 30 inches minimum and 32 inches maximum.
4. The clear span between the supports will be 28-1/2 inches.

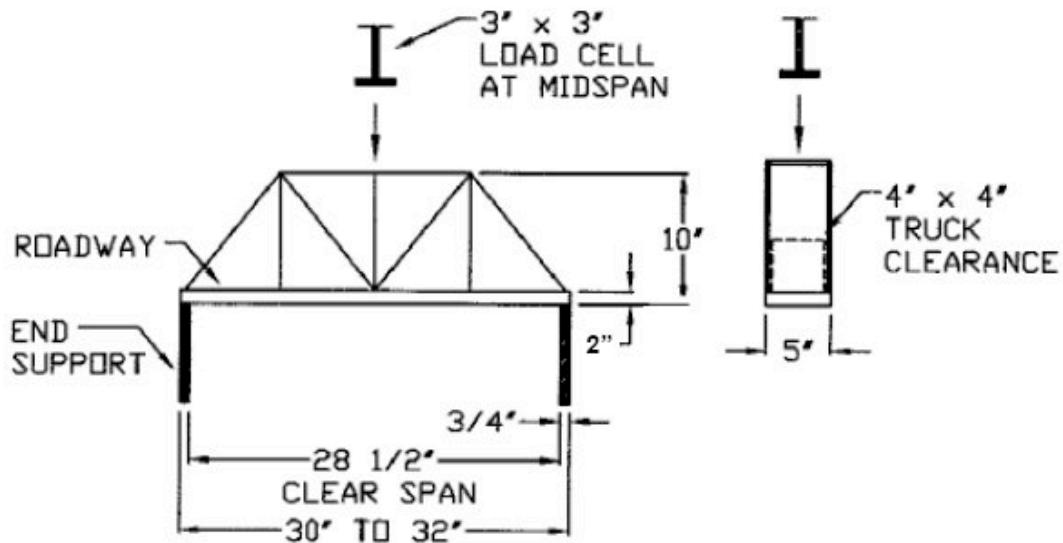


Figure 203.2

203.3 Weight.

1. The bridge must weigh 350 grams or less.

SECTION 204 - CONSTRUCTION

204.1 Roadway.

1. The bridge must have a roadway that can accommodate a 4-inch high, 4-inch wide vehicle.
2. The roadway must be continuous along its width over the entire distance between the supports.
3. No gaps shall exist in the roadway except where natural warping has occurred after the construction of the bridge.
4. No part of the roadway may exceed 2-inches above the end supports.
5. The roadway is the portion of the bridge to be loaded. A 3-inch square opening must be maintained above the loaded area.

204.2 Supports.

1. ASCE will provide two bridge supports for the bridge to sit on.
2. No special supports may be used.
3. The bridge may not exert any horizontal loads on the supports, other than friction.
4. The bridge must only come in contact with the top surface of the supports.

5. If your bridge is longer than the minimum 30 inches, we may ask you to mark where the end supports should come in contact with your bridge.

204.3 Members.

1. Members may be made of multiple sticks glued together in parallel. When viewed from one end they may form shapes such as:

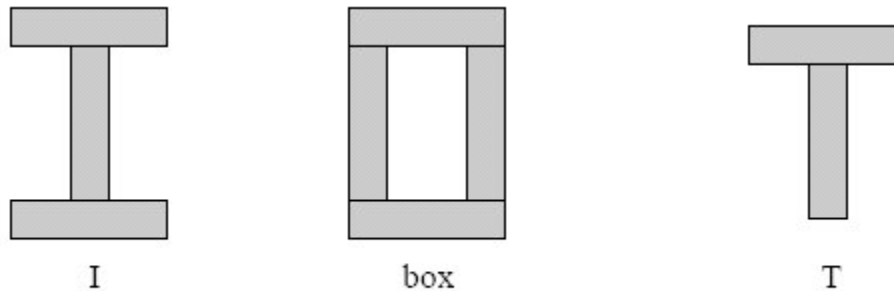


Figure 204.3a

2. All sticks must be visible for judging. No sticks can be hidden inside a closed section.

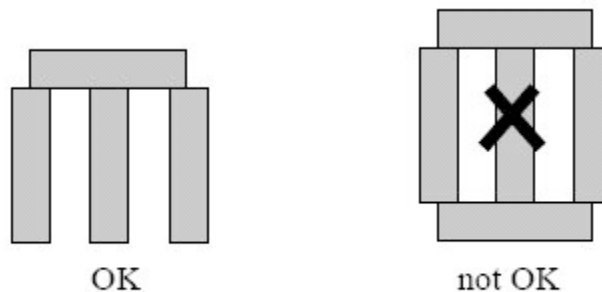


Figure 204.3b

204.4 Fifty Percent Rule.

Not more than 50% of any face of any stick may be laminated. For example, when using a full-length stick, the sum of glued lengths (1) and (2) must be less than or equal to half of the stick's total length (2-1/4 inches).



Figure 204.4.a

The length labeled (A) must be equal to or greater than half of the stick's total length (2-1/4 inches).

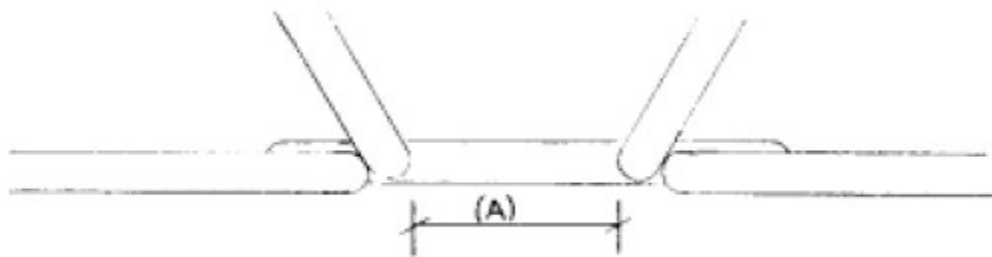


Figure 204.4.b

Edges of sticks may be laminated in their entirety, but if an edge is glued to a face, such as those shown in 204.3a, that face must follow the 50% rule.

204.5 Stacks and Gaps.

A maximum of six sticks may be stacked face-to-face at any joint. There must be at least a 1-inch clear gap between any two stacks. Stacks and gaps are illustrated below:

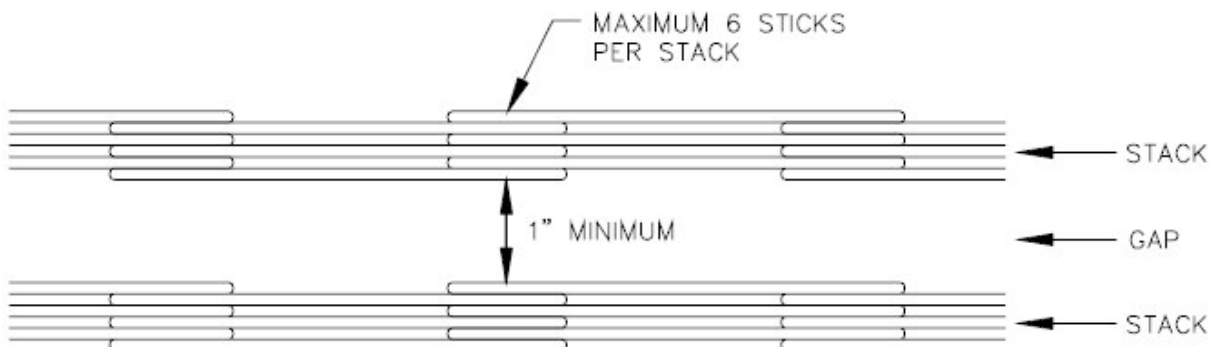


Figure 204.5

SECTION 205 - LOADING

The bridge will be loaded on the roadway at the midspan. The load will be applied on a 3-inch square plate placed on the roadway. A 3x3-inch square will be drawn on your bridge roadway at the contest during registration.

The bridges will be loaded to ultimate capacity during the competition. Bridges will break.

Chapter 3 - JUDGING

301 - FIRST JUDGING

A panel of technical judges will review the bridges for any rule violations. 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 contest registration.

After the technical judging, a panel of aesthetic judges will evaluate the bridges.

302 - CHALLENGES

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

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

303 - 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.

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.

Chapter 4 - FREQUENTLY ASKED QUESTIONS

Can we notch the members?

No. See Section 203.1

Can we drill holes through the members or cut slots in them?

No. See Section 203.1

Can we shave the members to make them thinner or narrower?

No. You may sand them lightly. See Section 203.1

Can we saturate the members in white glue?

Yes, but remember that the final weight must be 350 grams or less.

Can we paint/color the bridges or add decorations to them?

No. Section 203.1 restricts the bridge to only Popsicle sticks and white Elmer's glue.

Can we glue the sticks together to form a corner or "L" section?

Yes. Section 204.3 allows this construction.

Can we steam the sticks?

Yes. Sticks may be steamed to form curved shapes allowed in Section 203.1.

Does the 3 x 3 inch load area in Section 204.1 require clear access above it for the load to be applied?

Yes. The bridges are loaded from directly above the load area.

Can I Glue Sticks Face to Face in order to make the bridge deck?

No, sticks may not be glued face to face under any conditions. If you wish to reinforce your roadway, consider forming T-beams or I-beams, where a Popsicle stick face is glued to another Popsicle stick's edge (see [Figure 204.3a](#))

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. You may build a bridge with the roadway above the supports, but Section 204.1 states that no part of the roadway can be more than 2-inches 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. This makes sure each student is responsible for only one bridge and that 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?

Section 204.5 of the rules states that only sticks glued face-to-face are counted in a stack. That means you may glue other sticks to the stack as long as it is face-to-edge, not face-to-face. For example, you may glue sticks to the top and bottom edges of a stack or glue the edge of a stick perpendicular to a stack face. Remember, every stick must follow the 50% rule!

Chapter 5 - TIPS FOR BRIDGE BUILDING

Remember, judges will be making sure you followed all of the rules in Chapter 2. If you do not follow the rules, you won't be able to win prizes. Make sure you have read and understand the rules before building your bridge. If you still have questions, have your teacher e-mail 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 the design you are sure you can build. Think about how you will meet all the rules. Try using the West Point Bridge Designer at <http://bridgecontest.usma.edu/>

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.

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 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 or the structure probably will fail at that point.



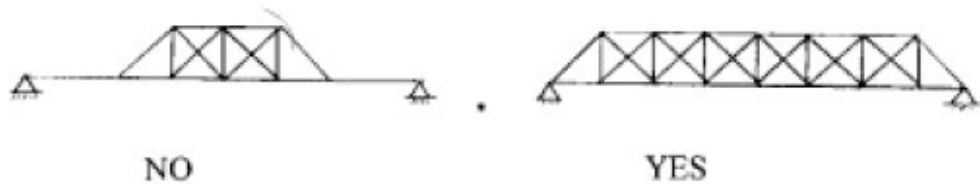
Before you build your entire bridge you may want to test small parts of your bridge and compare one design to another to see which is stronger. You can even test your stick connections.

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 28-1/2 inch gap. 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 the trusses, but the majority of the strength is needed in the main members spanning the 28-1/2 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.



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 last year's contest here: <http://www.flickr.com/groups/popsiclestickbridge> Keep in mind that the rules are different each year.

Plan ahead!!! Don't wait until the night before the contest to finish the bridge! (Wet or damp glue doesn't work very well.) You may have enough time at the contest to make adjustments if your bridge does not qualify. Bring some tools just in case.

Tools to help you with your bridge construction:

- pencil
- paper
- wire cutters for cutting sticks
- Exacto knife
- clips, rubber bands, and weights to clamp pieces together when the glue is drying
- and finally, PATIENCE !!! Good bridges take time to build.