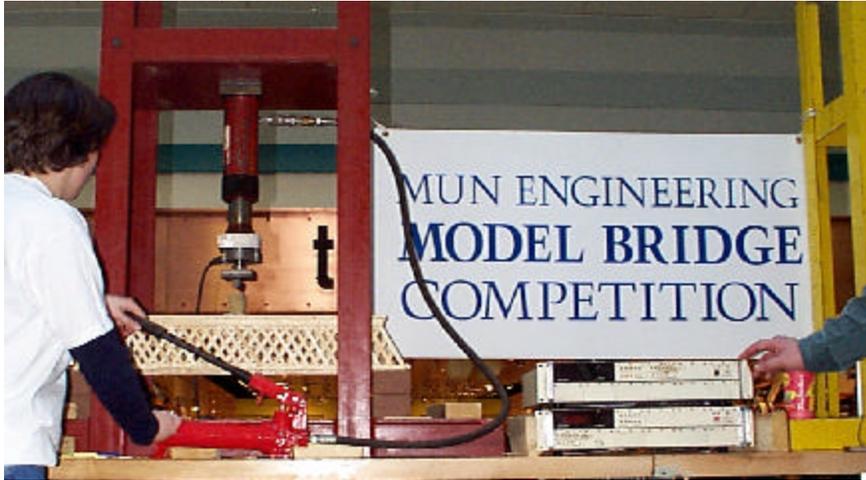


# HOW TO BUILD A MODEL BRIDGE



There are many different types of bridges. Some are simple bridges that have beams underneath to support the bridge deck like the type used for highway overpasses. This type is usually used for spanning things like roads or small rivers. Other bridges use truss design and can "span" wider roads or rivers or to support heavy loads like trains. Another type of bridge is a suspension bridge. Suspension bridges are used for very long spans. The word "span" means the distance between the supports that hold up the bridge. Most of the bridges that students build for the bridge competition are the truss type because they have a high strength to weight ratio but you can build any type of bridge as long as the bridge conforms to the rules.

## *How is a bridge built?*

Truss type bridges have a truss on each side and a section in between the trusses called the bridge deck. Deck beams that connect to the bottom cord of each truss support the bridge deck, where the test car drives over the bridge. There is also bracing that connect the tops of the trusses together to make sure they don't move when the load is applied to the bridge deck. A simple beam bridge just has two or more beams under the bridge deck with no trusses. One thing to keep in mind is that the weight of the bridge is very important.

## *Where to Start?*

First you must read and understand the rules of the competition. The main points are as follows:-

- The bridge must be constructed using only popsicle sticks and white paper glue, also called school glue. The reason for using white paper glue is to ensure everyone uses the same type of glue and white paper glue is the most common and easy to find.
- The minimum length of the bridge is 70 centimeters. This is to ensure that the bridge is long enough to fit into the testing frame and tested at a span of 60 centimeters (this will allow for 5 centimeters to rest on the testing blocks on either end of the bridge).
- The maximum height of the bridge is 30 centimeters and is measured from very the top of the bridge to the very bottom. This is to ensure that the bridge fits into the testing frame.
- The total outside width of the bridge should be a maximum of 15 centimeters. This is to allow a testing block (this is a block of metal measuring 15 centimeters by 10 centimeters) to be placed across the bridge deck to test the strength of the bridge.

There are also comments on the rules that help explain the rules a bit better. You should also read these. For purposes of this example, the following description refers to a truss type bridge with the trusses above the bridge deck. As long as you abide by the rules of the competition, there is no restriction on the type of bridge you can build. You can build a truss bridge with the trusses above or below the bridge deck, or both as shown in some of the photos, or even a beam-type bridge but the construction techniques will still be similar. There are many ways to construct a bridge, the following description is only one way but don't be afraid to experiment.

### ***But how do I build a bridge?***

**Step 1:** First you must decide on the shape and overall design of the bridge just as an engineer does.

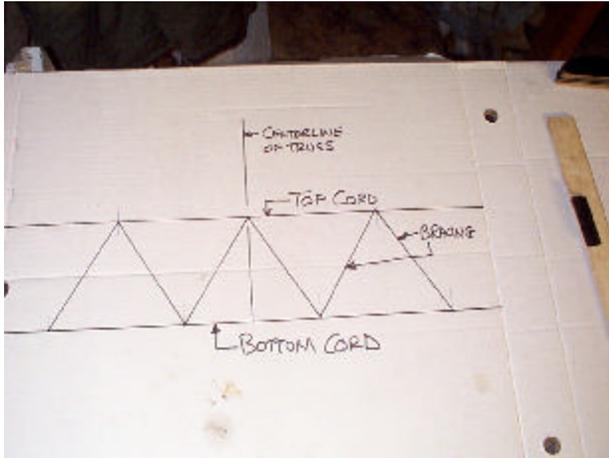
- Will the bridge be a truss type or a beam type bridge?
- Will the bridge have the trusses above or below the bridge deck or both?
- Will the design of the truss be square or curved?

Curved trusses are more difficult to build than square shaped ones but they can sometimes be stronger.

**TIP:** It's a good idea to sort through the popsicle sticks and pick out only the good ones. Any pieces that are twisted, cracked or have other imperfections should be put aside and used for filler pieces or temporary bracing. Use only the best sticks for building the bridge.

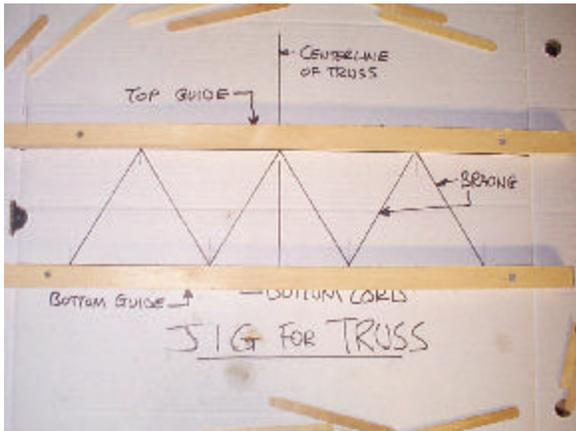
**TIP:** It's a good idea to make sure the sticks are kept clean so that the glue will bond to the wood. The better the bond the stronger the bridge.

**NOTE: THE BRIDGE SHOWN IN THE PICTURES BELOW IS NOT 70 CENTIMETERS LONG.**

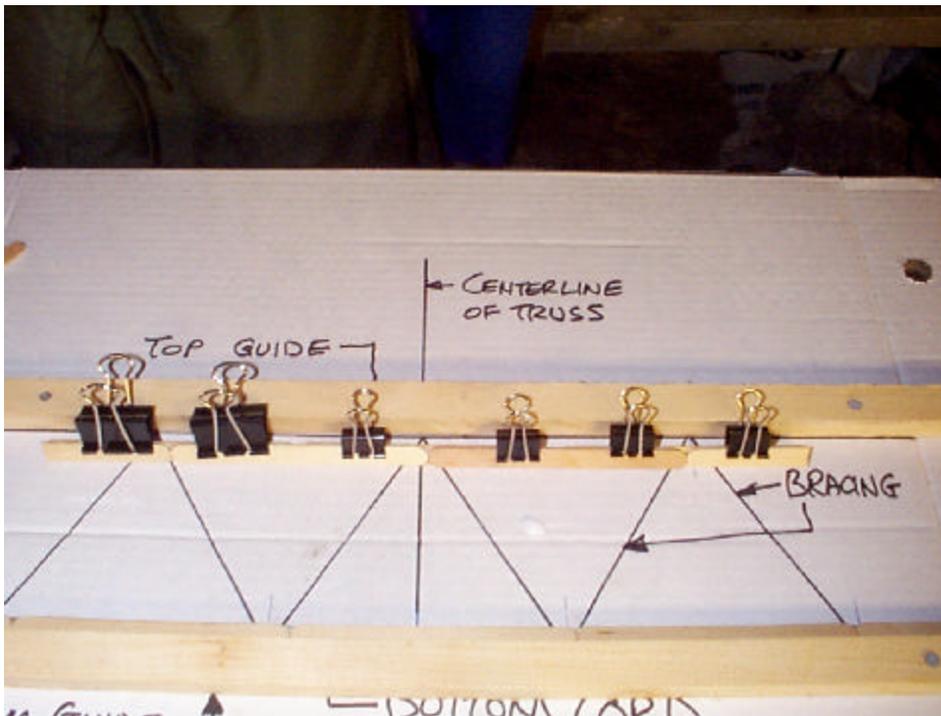


**Step 2:** Sketch out the shape of the bridge to full size on a piece of paper or board (here I used the back of an old pizza box laid on some rigid insulation for support). The sketch will tell you where each popsicle stick will go when you start gluing them together. The sketch will include the top and bottom "cord" of the bridge and the cross bracing in between the two "cords". The cords and bracing of a bridge are also called "members" and when glued together form the "truss". Certain members of the truss have to be stronger because they have to take more force when a load is applied to the bridge. You can demonstrate this by checking out the following WEB SITE ([www.jhu.edu/~virtlab/bridge/truss.htm](http://www.jhu.edu/~virtlab/bridge/truss.htm)). This site will allow you to design a simple truss bridge, apply a load to the bridge and see the forces in each of the members of the truss. One way to make certain parts of the bridge stronger is to glue several popsicle sticks together, this is called "lamination". When laminating popsicle sticks together you should stagger the sticks so the end of one stick is placed in the middle of the next stick. You can use large black paper clamps to hold the laminated sticks together while the glue dries.

## HOW TO BUILD A MODEL BRIDGE



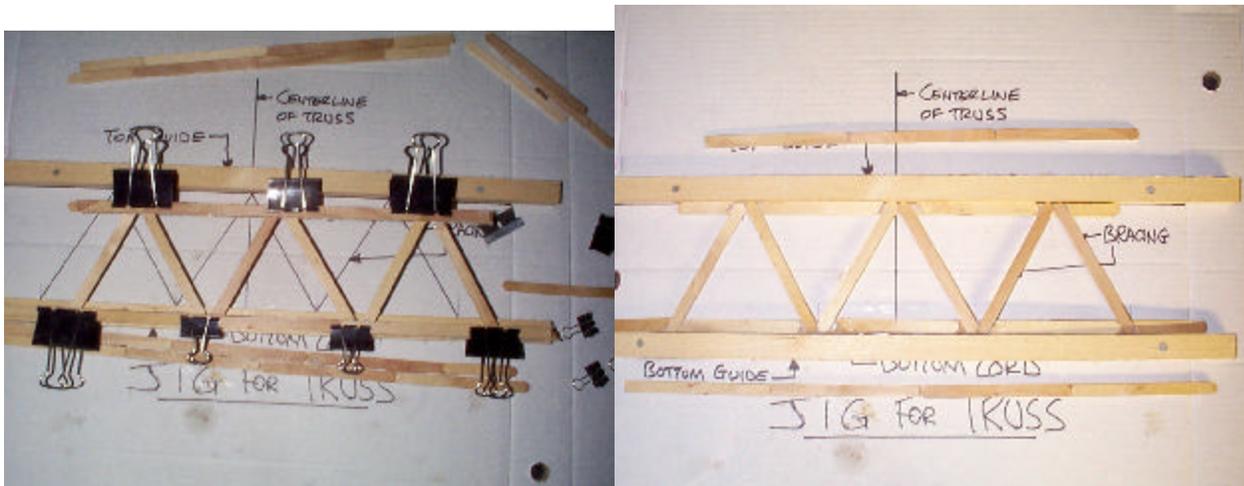
**Step 3:** Another trick is to make a form or "jig". You can make a jig by nailing two pieces of wood, about 2 centimeters square, to a piece of plywood along the top and bottom cord as shown in the picture. This will further help to make sure that the top and bottom cords of the truss are straight, symmetrical and the same size. First you laminate two or more sticks together to make part of the top cord and do the same for the bottom cord.



## HOW TO BUILD A MODEL BRIDGE

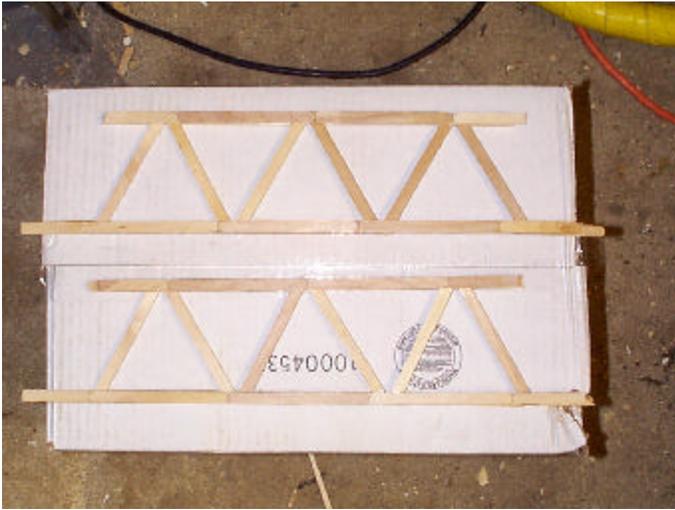
This picture shows two layers of sticks that have been glued and clamped. You will need 4 laminated pieces like this, 2 pieces for the top cord and 2 pieces for the bottom cord. When these four pieces have been assembled and clamped, they should be left to dry overnight. At this point the cords can be longer than required because they can be trimmed to the desired length later.

This picture shows the bracing and the four pieces, two for the top and two for the bottom cords, laid out ready to be glued.



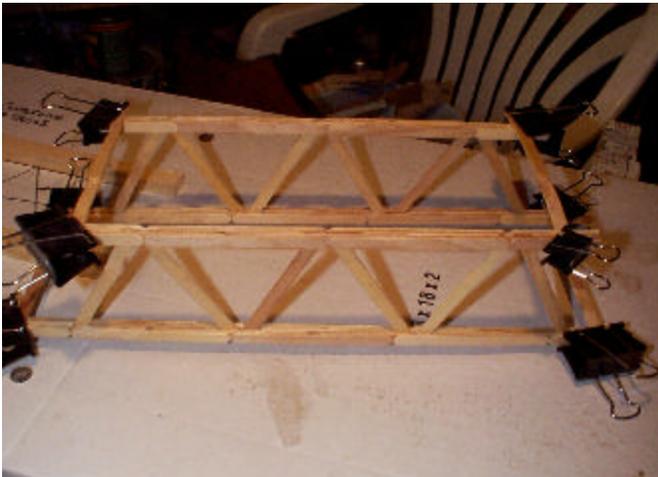
**Step 4:** Glue the cross bracing between the top and bottom cords. Because the cross-bracing will lay on the laminated piece of the cord you will have to fill in the space between the cross-bracing where the sticks are joined to the cords. Then glue the second sections you laminated across the top and bottom cords. The truss should then be removed from the jig, clamped and allowed to dry over night. It's a good idea to let the glue set a little bit before removing the truss from the jig because when the glue is wet the truss tends to be a little squishy. You may have to use a sharp knife to pry the truss from the jig but try to keep the shape of the truss while putting the clamps on.

## HOW TO BUILD A MODEL BRIDGE



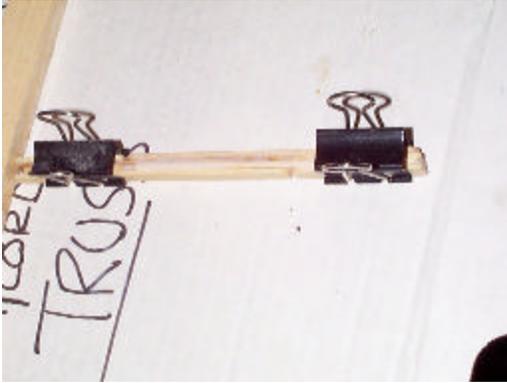
You have now completed only one truss. This has to be repeated for the second truss. This picture shows two completed trusses.

**NOTE: The bridge in this picture is not 70 centimeters long**



**Step 5:** The next step is to add the bridge deck. Making sure that the trusses are no more than 15 centimeters apart, clamp 4 temporary braces between the two trusses to form the shape of the bridge, 2 on the top cord and 2 on the bottom cord as shown in the picture (this bracing will be removed later).

**Step 6:** You will need to put some supports across the bottom cords of the two trusses to support the bridge deck, these are called "deck beams".



The width of the bridge is about 15 centimeters, which is longer than the length of a popsicle stick, so again you will have to laminate 2 – 4 sticks together to form the deck beams as shown in the picture above. You can space the deck beams as close as you want along the length of the bridge but the maximum distance shouldn't be greater than the length of one stick. After you have laminated the deck beams together, clamp them and allow them to dry overnight. When laminating the deck beams, you can make them slightly longer than the width of your bridge. These can be cut to fit when they are glued to the bridge.

**TIP:** You cannot build up a "pad" on the bridge deck where the testing block is placed during the testing of the bridge. This is because it will interfere with the test car that will be driven over the bridge by the judges. But you can use more deck beams under the center of the bridge where the test block will be placed.

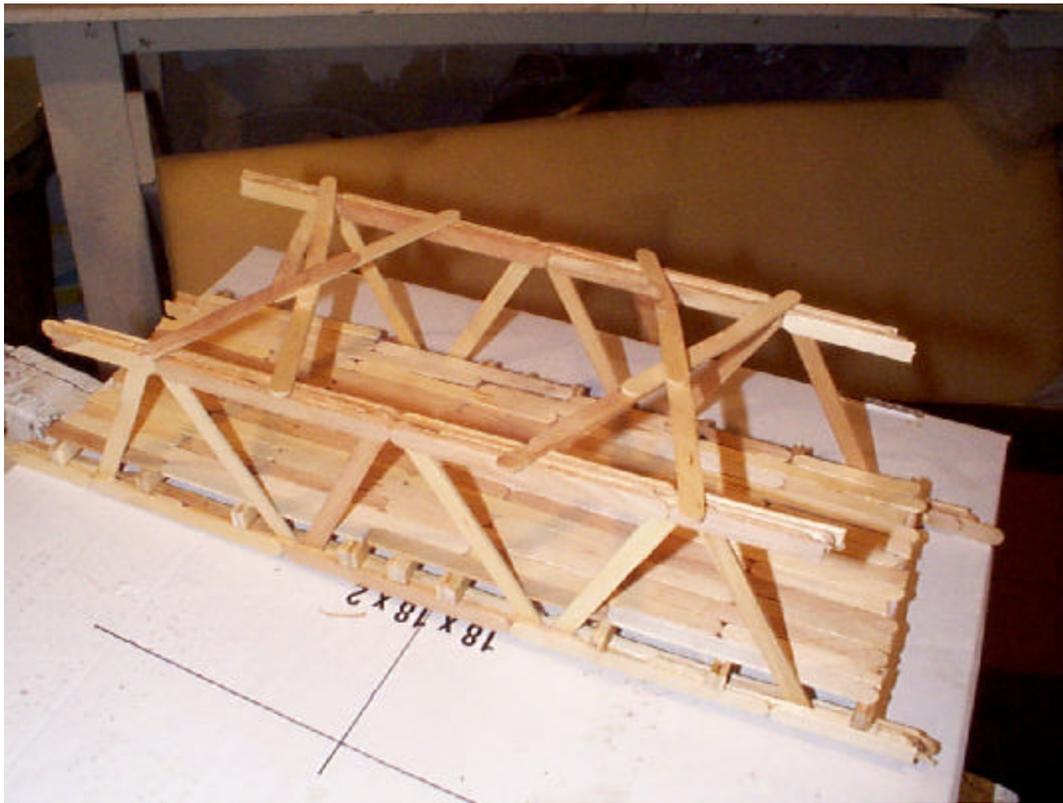
When all the deck beams are cut and fitted, glue the beams to the top of the bottom cord of the trusses and allow them to dry. It is important that the bottom cord of the bridge is flat and level so that the ends of the bridge, when finished, will sit properly on the testing blocks.

**Step 7:** Cut the ends of the top and bottom cords of the trusses that were left long when you started building the trusses in Step 3. Keep in mind the total length of the bridge must be a minimum of 70 centimeters.



**Step 8:** Glue popsicle sticks to the deck beams to form the bridge deck and allow to dry. Unclamp the temporary bracing used to join the trusses together and glue the top braces across the top cord of the trusses. Remember to leave an opening in the center of the bridge to allow the testing apparatus to be placed on the bridge deck.

*Voila, you have now completed building your bridge.*



*How is the bridge tested?*

## HOW TO BUILD A MODEL BRIDGE



The bridge will be placed in a steel frame so that each end of the bridge will rest on a block at each end of the bridge. The distance between the blocks, the span, will be exactly 60 centimeters. A long round steel tube attached to the steel frame will extend down and rest on the center of the bridge. An hydraulic mechanism will push down on the bridge in the middle of the span. An instrument will measure the force pushing down. The amount of force being applied to the bridge will be increased until the bridge fails. A bridge will be considered to have failed when the force measured by the gauge peaks and then falls or the bridge breaks. This is the maximum force that the bridge was able to withstand and will be recorded for each bridge tested.

**IMPORTANT: Mark your name and your school clearly on the bridge so it can be easily identified.**



*What do the judges look for?*

1. The first thing the judges will look for is whether or not the right type of glue was used. **IMPORTANT:** If the judges determine that white paper glue was not used in the construction, the bridge will be tested in the non-competitive category but will **not** be eligible for any prizes.
2. The judges will next check to see if the dimensions are as specified in the competition rules. Again, if the dimensions are not acceptable the bridge will be tested in the non-competitive category but will **not** be eligible for any prizes.
3. The judges will also look at the overall aesthetics of the construction of the bridge and the creativity put into the design. There will be a prize for the most aesthetic bridge.

The judges will then inspect the bridge and award up to a maximum of 30 points for two main things:-

- Quality of Construction (20 points) and
- Application of Engineering Principles (10 points).

For the Quality of Construction, the judges will look at a number of things such as:-

- Are the joints clean, tapered, cut to shape and show good connection between members and laminated sections?
- Does the bridge appear to be uniform and symmetrical?
- Does a test vehicle pass freely along the bridge deck?

For the Application of Engineering Principles, the judges will look at weight considerations such as:-

- Is there a minimization of weight or member size at non-critical points on the bridge?
- Does the bridge design utilize truss or beam development effectively?

***Web Sites:***

You can search the web using key words such as "truss" "structure" "bridge" "design"

[www.jhu.edu/~virtlab/bridge/truss.htm](http://www.jhu.edu/~virtlab/bridge/truss.htm)

[www.ce.ufl.edu/activities/trusslab/trussndx.html](http://www.ce.ufl.edu/activities/trusslab/trussndx.html)

[www.geocities.com/Baja/8205/truss.htm](http://www.geocities.com/Baja/8205/truss.htm)

[www.goldengate.org/](http://www.goldengate.org/)

***Photos of bridges built for past competitions.***

HOW TO BUILD A MODEL BRIDGE



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