Guidelines for Building a Model Bridge

1. INTRODUCTION

These Guidelines will help you to build a simple model bridge. Hints and tips are included to help make your Bridge Project a success. These Guidelines comply with the Rules for entering NAPEG's Model Bridge Building Competition.

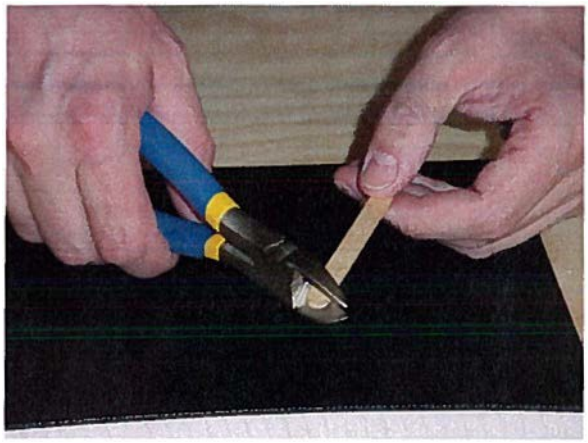
2. MATERIALS

You will need the following materials to build your model bridge.

Wooden Sticks (750 grams of sticks will be supplied to you when you enter the Competition).
White Glue (a bottle of glue will be supplied to you).

A flat, level working surface.
A straight edge, at least 70 cm long. (a piece of 2" x 4" lumber works well).
Clamps, or paper clips (used to apply pressure to glued joints).
A tool to cut the wooden sticks (cutting pliers are recommended).
A measuring tape.

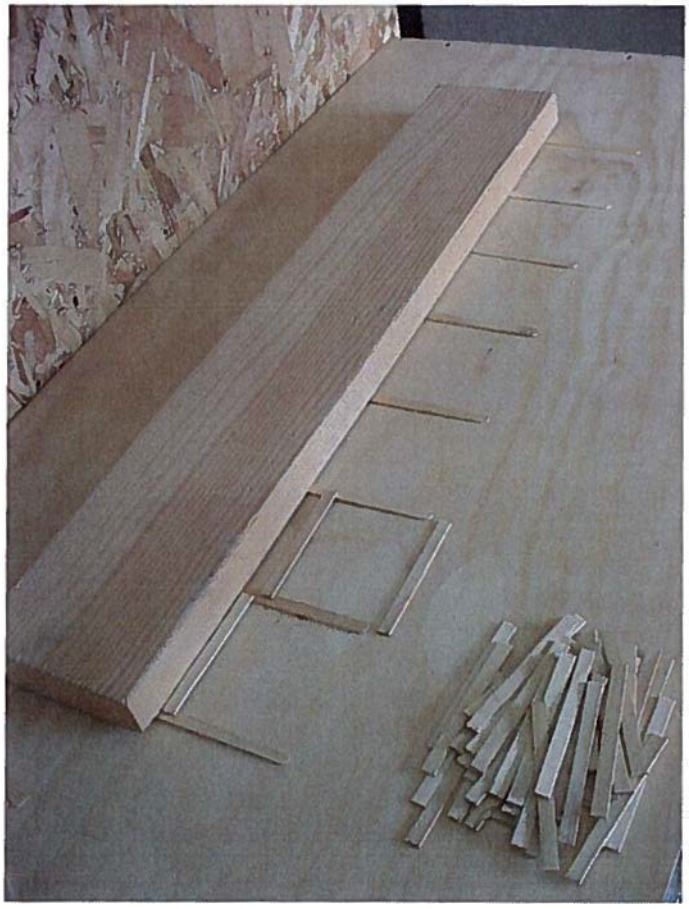
Photo 1. Materials needed for your bridge project.



Photos 2a & 2b. The cutting pliers easily cut the wooden sticks.

3. BUILDING THE MODELBRIDGE

A bridge has two general components - a deck across which traffic moves; and a support structure which is designed to transfer the load of the bridge and vehicles to the ground. Let's begin by building the bridge's deck.



Building the Bridge's Deck

For the purposes of our Competition, the deck need not be very strong. However, the deck must be long enough and wide enough to meet the requirements set out in the Rules. (It is the bridge's support structure that will be tested for strength.) This means that the deck must be between 60cm and 70 cm long, and it must be between 4 cm and 14 cm wide.

Photo 3 - Deck Construction. Begin by placing the deck's ribs partly underneath the straight edge and spaced about 5 cm apart. Prepare the sticks which form the deck by trimming the edges straight.

Photo 4. Next, glue the sticks which form the bridge deck to the ribs. Place the first row of sticks tightly against the straight edge (the 2" x 4" lumber), being careful not to glue the sticks to the straight edge. This ensures that the deck willbestraight.

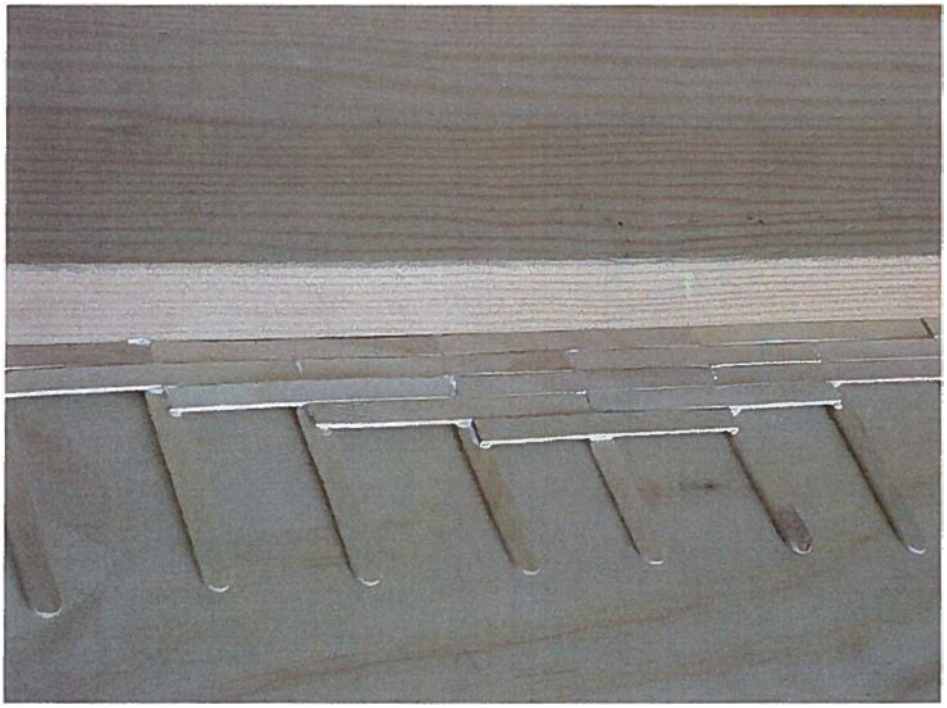


Photo 5. Now glue the sticks, one by one, onto the ribs. Continue this process until thedeck becomes the desired width. Our deck will be 6 sticks wide (although the photo shows only 5 sticks wide at themoment).

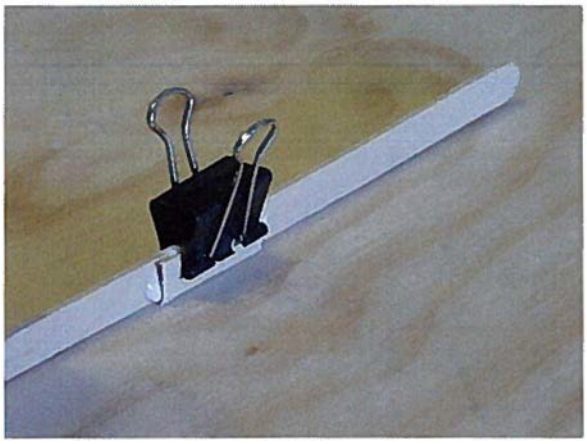
Photo 6. When you are done gluing the sticks, place a heavy weight onto the deck for several hours until the glue dries.

Building the Bridge's Support Structure (Trusses)

We will now build the support structure for the deck. We call this support structure a 'truss'. Two trusses are needed; one on each side of the deck. The Rules dictate size limitations for the trusses. They must be between 60 cm and 70 cm long. The trusses can be no more than 14 cm high.

Photo 7. We begin by loosely placing the sticks in the desired pattern on our work surface. (The truss is shown upside down in the photo.) A symmetrical pattern looks good. Use your imagination here. Any pattern of truss will work. Try to use triangles within your trusses. Triangles are strong structural components.

We must ensure that space is left for the metal bars of the testing apparatus. These spaces are represented by the black squares of paper in Photo 7. This makes more sense when you look at Photo 14, where the bridge is shown in the testing apparatus.



Photos Sa & **Sb.** Next, we glue joiners along the beams of our trusses. The beams are the long horizontal truss pieces at the top and bottom of the joists. Joiners are simply short pieces of wooden sticks. Be sure to clamp all glued joints until dry.

After the glue dries, we place a top beam and a bottom beam parallel to each other and about 10 cm apart on our flat work surface.

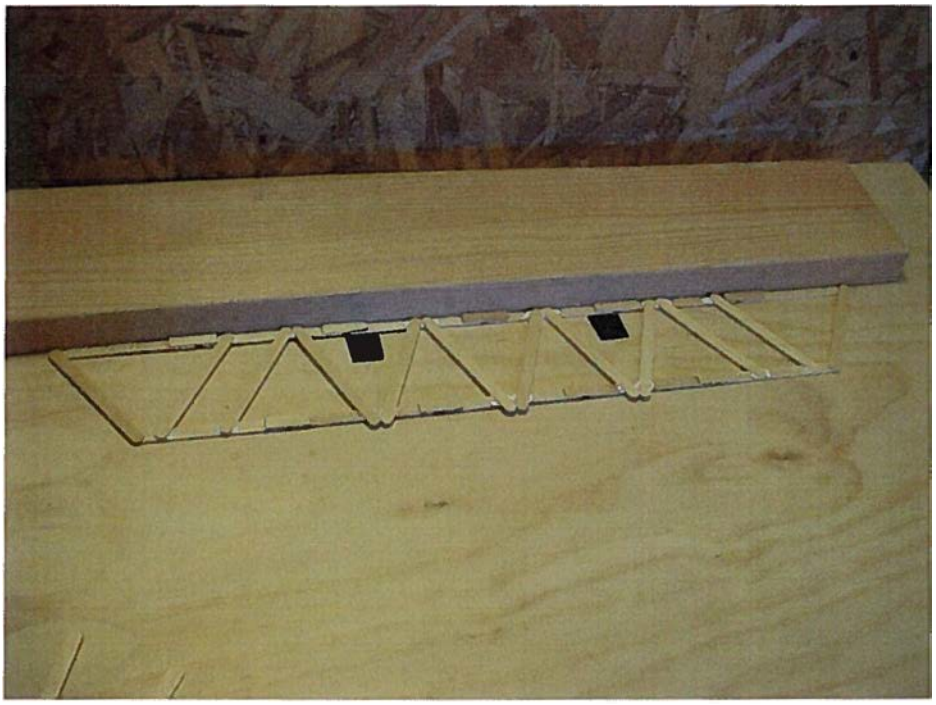
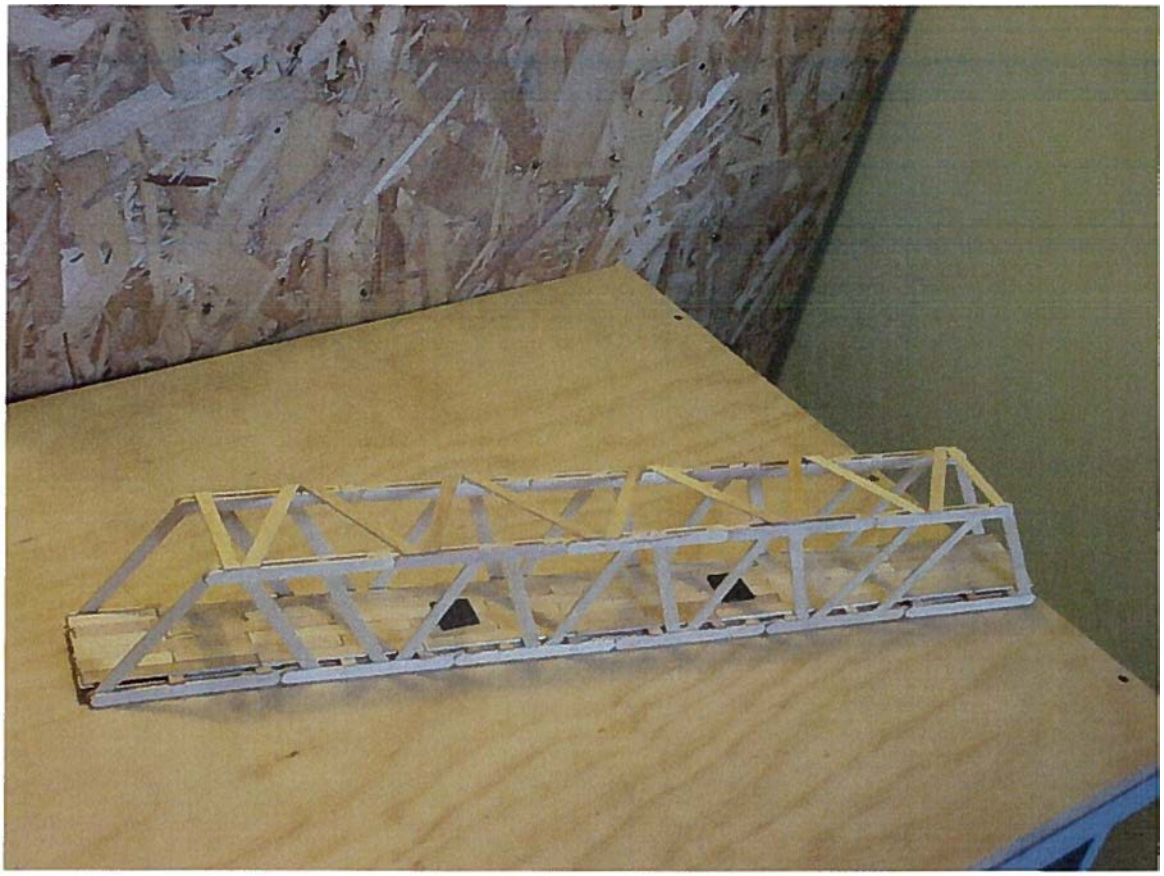


Photo 9. Now we glue the sticks between the two beams, as planned by our 'loose' pattern of Photo 7. Again, apply weight to the truss as the glue is drying.

Photo 10. Add a 2"d layer of sticks to the beams for extra strength. Trim off any excess stick ends.

Photo 11. When the two trusses are complete, it's time to attach the deck to the trusses. This is a very simple procedure, and it involves only gluing the ribs of the deck to the top of the lower truss beam. Don't worry if the deck ribs interfere with the truss triangles; you can trim off any ribs that interfere and simply putin additional ribs later.



Photos 12a & 12b. Next, trim off the excess pieces from the deck.

Add some bracing across the top of the bridge. Again, we have to allow space for the bars of the testing apparatus to stick through the top. See Photo 14.

Now our bridge is complete.

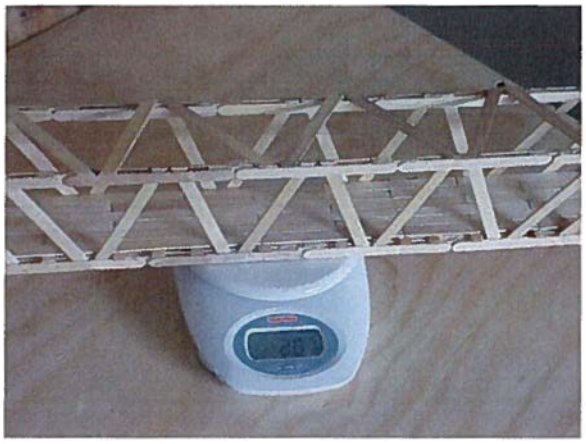


Photo 13. Our finished bridge weighs 207 grams, and it complies with all the Rules. See Table 1.

TABLE 1

Parameter	**Rules**	**Our Project Bridge**
Length	Between 60 cm and 70 cm	65cm
Width of Deck	Greater than 4 cm	6cm
Width of Bridge	Less than 14 cm	7cm
Height	Less than 14 cm	10cm
Weight	Less than 600 grams	207 grams

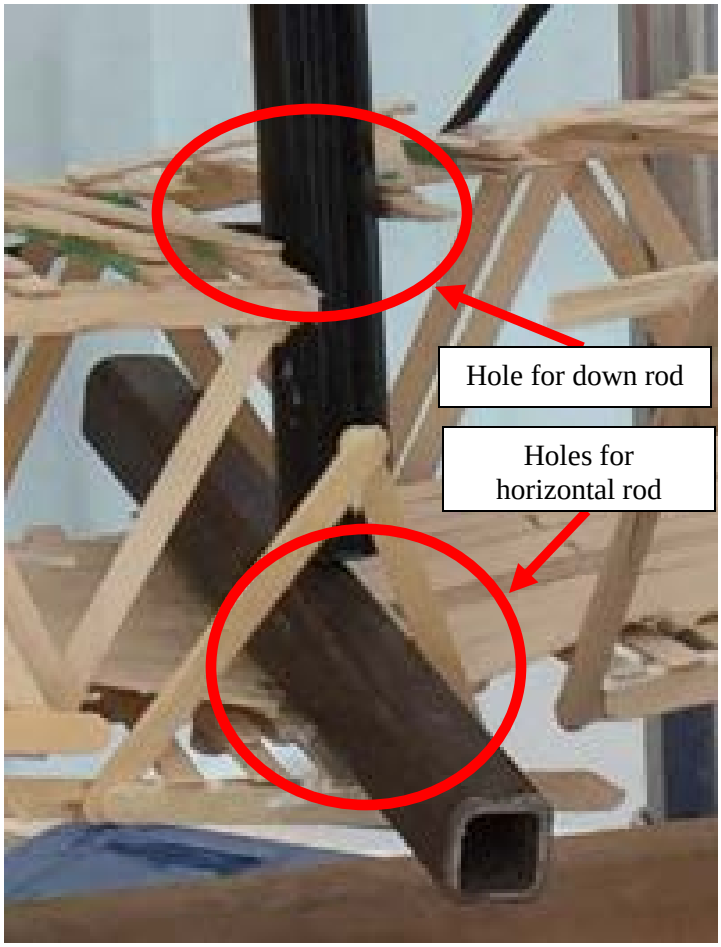
4. TESTING THE BRIDGE

Photo 14. We tested our bridge using the same testing apparatus that will be used during the official Competition. The testing apparatus pushes down through the top of the bridge (with the two vertical thin white metal bars) onto the two brown horizontal bars placed through the bridge. This produces a strong downward force intended to stress the trusses of the bridge.
It's important when building your bridge that your design allows space for these bars to pass through.

Our bridge supported 107.3 kg before it broke, when one of the sticks on a truss snapped.
This is indeed a very strong bridge.

Photo 15

Note that the bridge must accommodate the testing apparatus and allow a 3cm x 3cm opening on the top of the bridge for the down rod and a 3cm x 3cm opening on either side to allow the horizontal rod. These holes must be located at the center of the bridge.



5. Light Weight Bridge or Heavy Weight Bridge- Which is Better?

The formula we use to determine the strength of a model bridge is

$$\text{Strength Factor} = \frac{\text{Applied Force to Break the Bridge}}{(\text{Weight of Bridge})^2}$$

(This means Strength Factor equals the Applied Force to break the bridge divided by the square of the weight of the bridge. Applied Force means the amount of weight that we can pile onto the bridge to test when the bridge will break. Weight of the bridge means the weight of the bridge by itself.)

What does this formula mean? In the Competition, we want to achieve a high Strength Factor score. Building a strong bridge that can support a lot of weight (applied force) is a good thing, and that will increase your bridge's strength factor. However, building a heavy bridge that does not make good use of engineering principles is a bad thing, and you will be penalized for the weight of your bridge, not once, but twice (see that '2' in the formula?).

For example, let's say your bridge weighs 200 grams (0.20 kg), and it can support 100 kg. Its Strength Factor is 100 divided by (0.2)2 equals 2500.

Now imagine that your friend built a bridge that weighs 0.40 kg, and it can support 350 kg. Her bridge's Strength Factor is 350 divided by (0.4)2 equals 2187.5. Your own lighter bridge is the clear winner because it has the higher Strength Factor, although it can support much less weight than your friend's bridge.

A bridge twice as heavy must hold four times the applied force as the lighter bridge, to have the same Strength Factor. A bridge three times as heavy must hold nine times the applied force to have the same Strength Factor as a lighter bridge.

The important thing to remember is to apply every wooden stick in such a way that it transfers weight efficiently to the base supports. Try not to apply too many sticks that have no real structural purpose.

6. HINTS AND TIPS

a. Read the rules. Don't let your bridge entry be disqualified because of non-compliance with the rules. Remember to allow spaces in your trusses and top of the bridge for the metal rods of the testing apparatus.

b. While the glue is drying, apply a clamp or a weight to the joint. Also, make sure that the stick joints overlap sufficiently (at least 1 cm of overlap) and make sure you apply enough glue. In past competitions, many bridges have failed because their glued joints came apart too easily.

c. Build trusses for your bridge's main support structure. Besides the sticks used for the bridge deck, all other sticks should have a structural purpose, to transfer load applied to the bridge, to its base supports.

d. Use a straight edge to keep your bridge components straight as you are gluing them together.

e. Keep your bridge light weight.

f. Triangles are very strong structural components. The use of triangles in your trusses will make them very strong. Look at some real-life bridges to see how triangles are used in their construction.

Photo 15. Bridge nearJasper, Alberta

Photo 16. Pedestrian overpass, Yellowknife

THE END

This document was prepared
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Revised September 2018