

SAICE Model Bridge Building Competition:

Rules and Guidelines to the Competition

Originally by A.D.W. Sparks, B. Holdridge and A. Clothier.

Edited by G du Toit



Synopsis

This short paper provides a guide for school learners and to organisers of the SAICE Model Bridge Building Competition.

Introduction

Model Bridge Building Competitions for school learners have become an integral part of the activities of the South African Institution of Civil Engineering (SAICE). The history and alternative forms of model testing will be described elsewhere.

The Manner in which the competition will be run

The steps in the bridge building competition are as follows:-

- 1) This set of rules will be issued to each school team accepted into the competition. This set of rules is a *basic* set of rules.
- 2) Construction kits will be issued to the teams on the morning of the competition or the stated period ahead of the competition if they are building remotely.
- 3) The clear span distance for the bridges will be announced when the construction kits are issued to the learners.
- 4) On the website the local organising committee might decide to provide a preliminary lecture on the interpretation of these rules, and on aspects of model bridge construction.
- 5) Each school team will construct a model bridge using the kits supplied. Guidance on the interpretation of the rules will be provided, on request using a frequently asked questions function on the Website. Teachers, parents and friends are not allowed to build the bridge on behalf of the learners or to provide assistance which would materially influence the construction of the bridge.
- 6) The model bridge must be completed within a certain time.
- 7) At the time of testing, if possible at the time, the members of each team will be required to load their own bridge model until it fails.
- 8) The score for each bridge includes a score for aesthetic value, plus a score for the

maximum load which it carried.

- 9) The rulings of the appointed judges will be Final.
- 10) All members of the organizing committee are voluntary workers who make decisions and arrangements in good faith. The SAICE and its office bearers are not responsible for any injuries losses or inconveniences which might arise. Please see the Liability disclaimer at the end of the rules.

The Rules

The contents of the kit issued to teams on the day of the competition, are described below. Substitute or additional material is not permitted.

Items within the kit from the SAICE organisers

- 25 wooden sticks (approximately 5mm x 5mm x 600mm).
- A selection of glues.
- A cardboard deck to be placed within the model.
- Three metre length of strong cotton string which can be used in the final model.
- Some thin (coloured) string for temporary clamping this is not part of the final model.

Glue

Glue kits will be provided for constructing the model bridges. Please familiarize yourselves with the glues provided and their respective properties. If epoxy glue is used, it should be thoroughly mixed (e.g. on a cardboard card prior to the application of the mixture to the wooden joints). Do not mix epoxy glue directly on the joints, as this may result in almost zero strength of the glue.

Imperfect wooden sticks

The wooden sticks are cut from pine wood. Teams who build in person will be able to swop out sticks should they feel that the sticks they have been issued are not suitable. The sticks have been selected randomly for each kit and have been vetted by the organisers. There will be imperfections in every kit. Please thus select your timber members appropriately.

Bridge must be longer than the clear Span

The *Clear* span of the bridge is the gap of the ravine over which the bridge will be built. This is also the clear gap on the testing bed. The total length of the final bridge should be at least 60 mm longer than the clear span. A team will not be disqualified if the length of bridge is more than 60 mm longer than the clear span, but it must be understood that the total mass of the bridge will increase.

The clear span, which is specified when the kits are issued, is usually longer than the longest stick that is provided. Rules exist with regard to the method of joining or overlapping two sticks. See the section on "overlapping". Severe penalty points apply to a model bridge if its length is equal to, or shorter than, the clear span.

A cardboard piece is provided for the deck of the bridge

A cardboard piece is provided to form the deck of the bridge, i.e. the road surface. It may be glued on top of crosspieces, which join the two sides of the bridge. This deck must run the whole length of the bridge.

See Figure 1 and Figure 5c.

Clear Passageway required for traffic

A clear passageway must exist along the whole length of the bridge. This passageway must be 100 mm wide (i.e. inside dimension of bridge) and of height at least 100 mm above the cardboard deck.

Loading apparatus must fit the bridge

Teams are advised to study the dimensions provided for the loading apparatus. During testing the load will be located under the centre of the bridge. Please ensure that the loading device can be threaded through the side of the bridge, See Figure 2. The loading device may not be borrowed from the organisers during construction of the bridge, so please check the dimensions provided carefully.

The loading device will either sit on the cardboard deck, or it can be supported in the region of the deck on the top of the side beams of the bridge (e.g. if these side beams are slightly higher than the deck See Figure 5c).

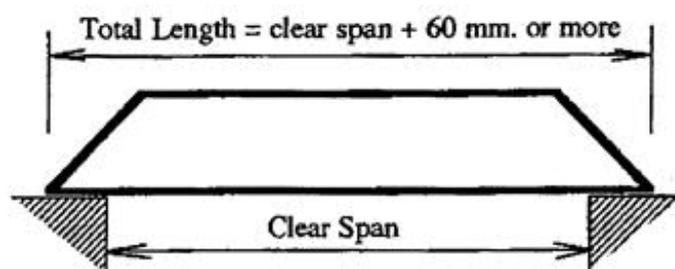


Figure 1.

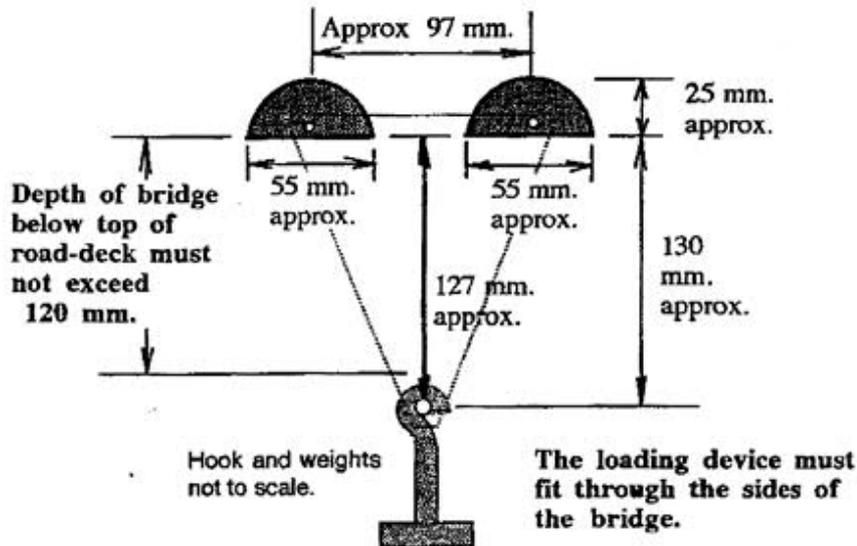


Figure 2a - Approximate Dimensions of a Loading Device :-
Please check the dimensions of the device at your venue.

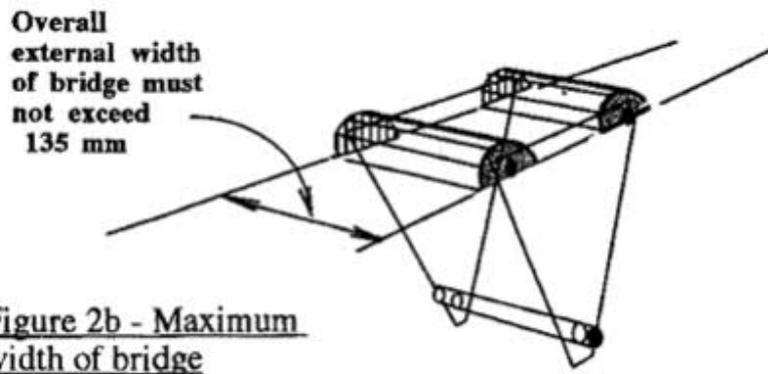


Figure 2b - Maximum width of bridge

Limit to bridge depth below the level of the roadway deck

The loading device has a horizontal rod about 140 mm below the level of the deck. A rope runs vertically down from this rod and through a pulley system to the long hook onto which the weights are added. The bridge depth, measured downwards from the level of the roadway, may not exceed 120 mm at the centre of the bridge.

Suggested method of construction

Start early, by planning the bridge. This is best done on a large sheet of paper clearly indicating the extent of the span to be achieved and any other spatial limitations. Once the bridge is

planned check that you have sufficient wood for the bridge design proposed. Start by constructing the most important members of the bridge, as the glue may be slow to dry. Read the section on "overlapping members". Use a firm surface for the bridge building and place newsprint or other protective covering on the surface to prevent damage.

Teams are encouraged to use cutting tools such as an X-Acto type knife or a Stanley cutting knife, in order to make smoother cuts in members at the joints.

When the sides of the bridge have been completed, the cross members between the two sides can be glued in place. Remember that the deck must fit on the bridge. Extra strength can be gained by glueing the cardboard deck to its supporting members. All four support corners of the bridge must be in the same plane.

Several methods for clamping Joints

- 1) The easiest method is the use of a soft board backing and pins to hold the wooden members in position.
- 2) Clothes pegs are also useful for clamping joints.
- 3) A thin piece of string (usually coloured) may also be provided which may be used on a temporary basis to hold together joints or portions of the bridge. This string must be removed prior to testing, and may not form part of the final structure.
- 4) Teams may use clamps to hold together two or more members at a glued joint.
- 5) It is believed that methods (1), (2) and (3) are very efficient, and little advantage is gained if teams use extra joint clamps.
- 6) If the glue requires a long period in order to set, then the model can be clamped in place as shown in Figure 3. If the glue is quick drying, then it is still necessary to clamp certain members to be in the same place.

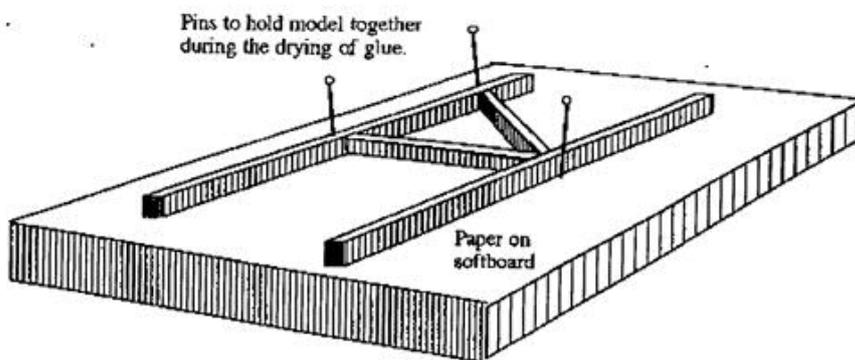


Figure 3 - Using pins and a soft board

Overlapping and joining of members

Two pieces which are running in the same direction (and this includes spacers) may not be

glued together for a distance longer than 10 mm at any one spot. It is also not permitted to lay two pieces directly alongside each other (face to face) and merely glue them at points along their length. In this latter case spacers must be used. Each spacer may not be longer than 10 mm, and the spacing between the spacers should not be less than 50 mm.

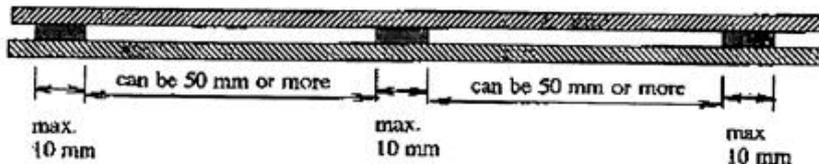


Figure 4a - Spacers

1. Joining two members in a butt joint (Figure 4b), leads to a weak joint, especially if this is used in a tension member.



Figure 4b - Butt Joint - a weak joint

2. A butt joint can be strengthened by using side pieces.

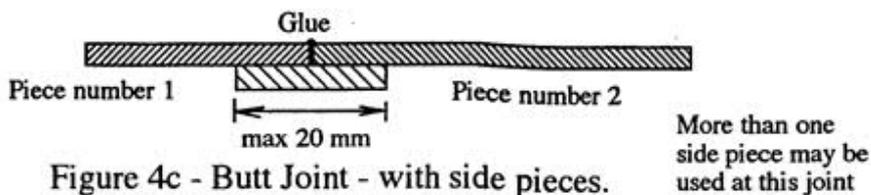


Figure 4c - Butt Joint - with side pieces.

3. A spliced joint is a stronger joint than a butt joint (See Figure 4d) Side pieces (20 mm long) may also be used on the sides of this joint.

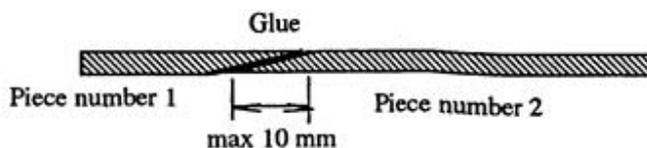


Figure 4d - Spliced Joint - a stronger joint than a butt joint.

A simple lap joint of two members

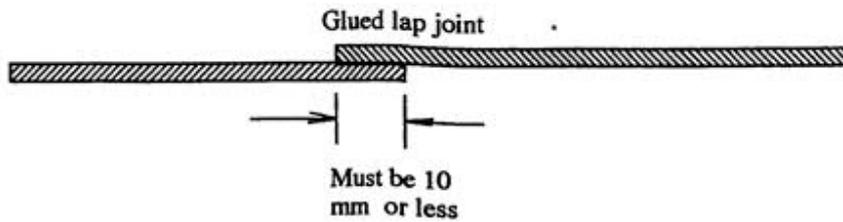


Figure 4e - Permissible Lap joint

Building up compression members

It is known that compression members first buckle sideways when loaded. Thereafter they deform too far in the sideways direction, at which stage they break. A single stick of wood can more easily carry a tension force than a compressive force. Members which carry large compressive forces must be strengthened. The members along the upper outline of the bridge (top chord) are usually the compressive members.

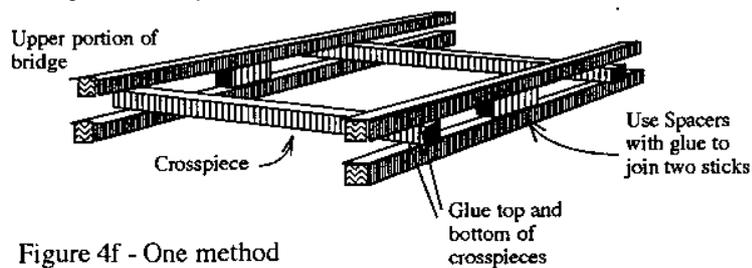


Figure 4f - One method

Compression members can also be built up from more sticks.

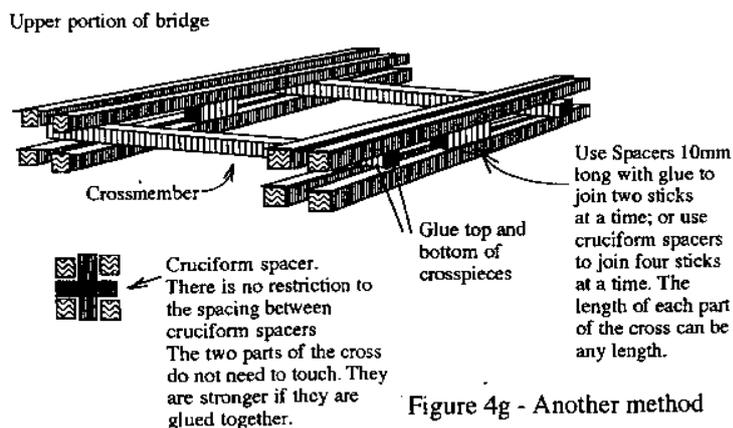


Figure 4g - Another method

The vertical portion of any cruciform spacer can be one of the vertical members or one of the diagonal members of the bridge, and the horizontal portion of any cruciform spacer can be one of the horizontal members of the bridge. Diagonal members in the horizontal plane, can also be used as one of the horizontal portions of a "cruciform" type spacer.

Using Three Sticks

The three sticks in Figure 5a are too close together. As a unit they do not provide much compressive strength. They should be further apart.

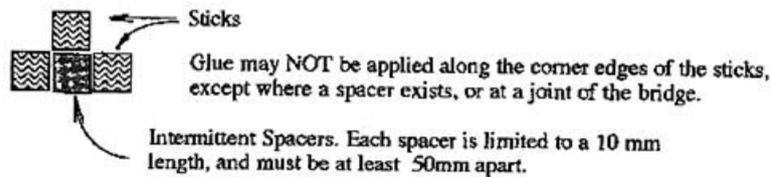


Figure 5 a - You may use three sticks.

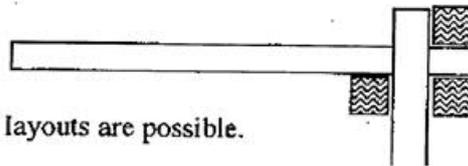


Figure 5 b - Other layouts are possible.

Other layouts for three or more sticks may be used. For the different sticks to act in unison, they should be joined by spacers along their lengths at intervals.

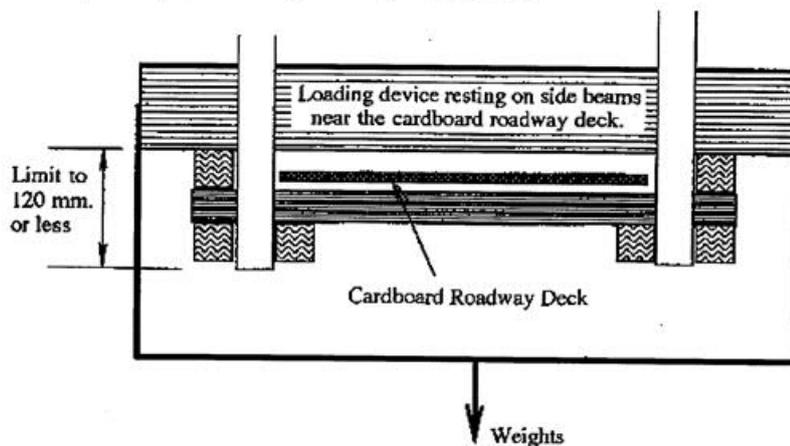


Figure 5 c - Section at Deck Level - Note that the Loading Device can rest on the side beam instead of on the cardboard deck. Note, the limit of 120 mm to underside of bridge. See above figure.

No restrictions on glued length at bridge joints

The position where members come together from different directions is known as the bridge joint. There is no restriction on overlapping glue distances at a bridge joint. Members can also come together at a bridge joint from any direction.

An extra length of strong- string

You may be provided with a 3m length of strong string which you may use in any

manner as part of the final structure. It may be cut and knotted, or stuck to portions of the bridge. If a team decides to unravel the string and to use its separate pieces, the team is required to warn the organisers that this unravelled string is not part of the thin string used for temporary construction (the latter is discarded prior to testing).

Bracing of bridge against supports

Up to the present, we have prevented teams from designing bracing against the abutments which support the bridge. But if suitable testing frames exist, then it may be announced by the organisers that bridges which brace against abutment supports will be permitted. The testing frame will be available for measurements. Teams should anticipate that such an announcement may be made on the morning of the competition. Teams should have thought about two different types of design prior to the competition. If permitted, bracing will not be compulsory.

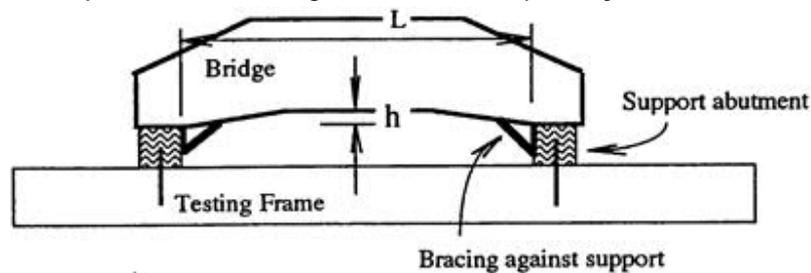


Figure 6 - Support Bracing - if permitted by organisers.

Roadways which are not level

Some teams wish to use a slightly humped roadway, even in conventional bridges which are not braced against their supports. The maximum hump distance permitted is $h = L / 6$ where L = the clear span.

Aesthetic Value

The judges will first give an aesthetic value to the bridge (e.g. out of 30 points). The aesthetic value will depend mainly on the form or shape of the bridge. The simplicity of design is important. The members of a structure should be those that are obviously necessary for its stability. Extra frills usually detract from the simplicity of the structure.

Does the bridge look as though it is a bridge designed to carry loads.

A bridge that looks like a roof truss (i.e. high centre point diminishing to zero height near supports) may be able to carry a high load, but it might receive a lower

aesthetic score than a model which looks like a bridge which will carry a moving vehicle. Neatness of workmanship will also be a factor.

Testing Procedures

The mass of each bridge will be measured prior to the load testing. The order of testing will be decided by the judges. Bridges will be centrally loaded until they fail. Usually this will be done by using dead weights which are applied by the members of the respective team. The starting load may be stipulated to be 50 percent of the previous highest load achieved by other bridges previously tested on this day. Judges will decide whether a load has been carried for long enough (e.g. five seconds).

Decision of the judges

The decisions of the judges will be final. The winning bridge may, after testing, be retained by the judges and may be subjected to further examination.

Disqualification

Each model bridge will be inspected, and any violation of the above rules can cause immediate disqualification or a penalty score. The judges may allow a bridge to be corrected to comply with the rules.

Liability

The South African Institution of Civil Engineering (SAICE) and other sponsoring organizations, and the members of the SAICE do not accept liability for injury or inconvenience to members of teams, or to members of the public during the competition, during the loading of the bridges and during travelling to and from a competition. Such risk is carried entirely by the team and its members.

Suggested formula for judging bridges

The following formulae have been found to be acceptable. Either of these two formula may be used:-

Score = Aesthetics out of 30 $+ 200 \times \left\{ \frac{\text{Failure Load kg}}{\text{Mass of Bridge .grams}} \right\}$
Score = Aesthetics out of 30 $+ 20 \times \left\{ \frac{\text{Failure Load Newtons}}{\text{Mass of Bridge grams}} \right\}$

Figure 7 - Suggested Formula for scoring

Items which teams may use for the competition

1. Pocket calculator for trigonometric calculations
2. Drawing instruments e.g. pencils, protractor, tape, rulers, set squares
3. Cutting tools such as X-Acto, Stanley knife and sand paper
4. A block of wood for cutting e.g. with a small stop
5. Small weights to place on joints while the glue dries (e.g. these can be small sealed bags filled with sand).
6. Small clamps for holding sticks together at a Joint. These will probably not be necessary as other clamping systems are provided).

Items which teams may NOT use for the competition

In the spirit of the competition teams may not use previous models of bridges, or predrawn sketches of bridges. Boards devised by teams as jigs for laying out bridge systems are not permitted. Teachers, parents and friends may not support the learners while model bridges are being built. No electrical tools will be allowed.

The spirit of the Competition

Due to the nature of the competition it is very easy for teachers and parents to want to get involved in assisting their learners. By all means we would encourage mentorship and coaching of the learners, but please do not direct their efforts or assist in any way that would provide the learners an unfair advantage.

The bridge building competition is a wonderful opportunity for learners to design and construct something substantial out of the limited resources with which they are provided. We hope that through this process they will be inspired to learn about engineering, materials science, and the fundamentals of solving problems and making things work. Please thus respect them and other learners by letting them build the models themselves and learn from the process.