



## Guidelines 2019

### 1 Overview

**Please note: the guidelines and kit have changed for the 2019 Aurecon Bridge Building Competition. Please read these guidelines carefully to ensure you comply.**

Welcome to the Aurecon Bridge Building Competition. Using materials supplied by Aurecon, students are tasked with designing and constructing a model bridge using the construction guidelines provided. Judging days take place in September, and all competitors are invited to gather at venues across Australia and New Zealand where bridges are load tested and assessed for visual appeal, workmanship, creativity and functionality. The competition is open to Years 8 and 9 students in Australia, and Years 9 and 10 students in New Zealand.

Once again, participants are encouraged to take part in the [optional digital component](#) to reflect the increasing role virtual/online environments and programmes play in the engineering and testing of bridges.

As with previous years, schools will still have the opportunity to physically construct a bridge from the kit of materials provided to them and the Judging Days will run as usual – i.e. the bridges will be judged for efficiency, strength, and innovation.

In addition, and as a way for students to better plan and design stronger bridges, all schools will be encouraged to design their bridges digitally first via, [AutoCAD](#), [SketchUp Make](#) or [SketchUp Free](#). Both SketchUp and AutoCAD programmes are free for schools to use. AutoCAD and SketchUp Make are desktop programs that can be downloaded to your computer, and SketchUp Free is based on a web browser.

Teams are encouraged to submit their digital wireframes to Aurecon to compete for the Digital Award for the best virtual bridge design. To be eligible for the Digital Award, teams must:

- Use the digital tool [AutoCAD](#), [SketchUp Make](#) or [SketchUp Free](#). For further information please see [section 4.2](#) of this document
- Submit their digital wireframe designs to Aurecon via email [by 11.59pm on Monday 5 August 2019](#)
- Submit a physically constructed bridge at your location's Judging Day in accordance with these guidelines

Visit the [Aurecon Bridge Building Competition website](#) for more information and the confirmed dates for the Judging Day at various locations.

### 2 The brief

#### The Problem

There is a town called Newvale which has recently seen a large population growth. It is situated alongside a beautiful river with plenty of nearby parklands, and a pristine beach on the opposite side. With a new central business district and shopping centres and schools popping up all over town, Newvale has become a popular choice with young families moving to the area.

Many of the natural wonders of Newvale, including the pristine beaches are on the other side of the river. The residents of Newvale want to be able to go on hikes on the weekends and have picnics with their families or visit the nearby beaches. However, currently they must drive an extra 40 minutes inland to cross the river. This also impacts the flow of trade in and out of the town, with freight options being limited to the main inland road.

To counter this, the City Council of Newvale has seen the opportunity to build a bridge across the river closer to the city. The bridge will help boost the local economy with easier trade between neighbouring cities and provide the residents of Newvale with an improved lifestyle.

## **The Task**

The City Council of Newvale has commissioned your expert bridge building team to design and construct a bridge for their city. The bridge must transport goods across to the other side of the river, and allow the residents to drive, cycle or walk across it. The bridge must be strong enough to handle the strong winds that the town sometimes experiences, but also visually beautiful to fit in with the aesthetic of Newvale.

It is important that bridges have sustainable, innovative and economical designs, so ensure your bridge meets these main priorities to be chosen as the winning team.

The City Council of Newvale is also looking for forward planning of bridges so they can test the strength of the bridge before construction. To help you plan and design an even better bridge, it is strongly recommended that you use the digital tools [AutoCAD](#), [SketchUp Make](#) or [SketchUp Free](#) prior to constructing your bridge.

The mayor of Newvale is looking for a variety of bridge designs that showcase efficiency, strength, and creativity. Will your bridge design be chosen to provide critical infrastructure to the city of Newvale?

## **3 Specifications**

### **3.1 Bridge specifications**

To improve the strength of your bridge, it is greatly encouraged to plan and design your bridge digitally in [AutoCAD](#), [SketchUp Make](#) or [SketchUp Free](#) before you begin building it. This will ensure you don't run out of materials, that your design is structurally sound, and will also give you the opportunity to compete for the Digital Award. If you prefer to not compete for the Digital Award and simply just construct your bridge, you will still be eligible for all other awards on Judging Day.

Your bridge must be built within certain specifications outlined below. To apply the testing load cell, a purpose-built rig will be used on Judging Day.

Please refer to Figures 1 – 4 to see the rig and bridge dimensions, and Figures 5 – 10 for examples of building techniques with the materials.

#### **3.1.1 Span**

Your bridge must have a total length of 700mm to span across the clear 650mm chasm between the supports of the testing rig. Take into account that your bridge will be resting on the testing support frame (refer to point A on [Figure 1](#)).

#### **3.1.2 End supports**

The width of your supports at each end is 25mm (refer to point B on [Figure 1](#)).

Your bridge cannot rely on the testing support frame for *lateral support*. Side thrusts onto the vertical faces of the frame is not permitted.

#### **3.1.3 Width**

Your bridge must be no wider than 140mm (refer to point C on [Figure 2](#)).

#### **3.1.4 Depth**

The maximum allowable depth of the bridge below the load bars when placed in the loading position is 180mm (point D [Figure 1](#)).

### 3.1.5 Load bar clearance

A clear opening for the two load bars must be accommodated in your bridge design. Two areas at least 20mm high, 50mm wide and 30mm apart, are required to place the load bars on the bridge deck area.

The load bars and hanger assembly must be able to fit in the central region of the *bridge span*, not at the *ends of the span* (refer to point F on [Figure 1](#)). The load bars can either go through or be placed over the top of the bridge.

The load bars should be able to be placed no more than 200mm below the supports to allow the load cell and test weight to be put into position (refer to point G on [Figure 1](#)).

### 3.1.6 Road and car

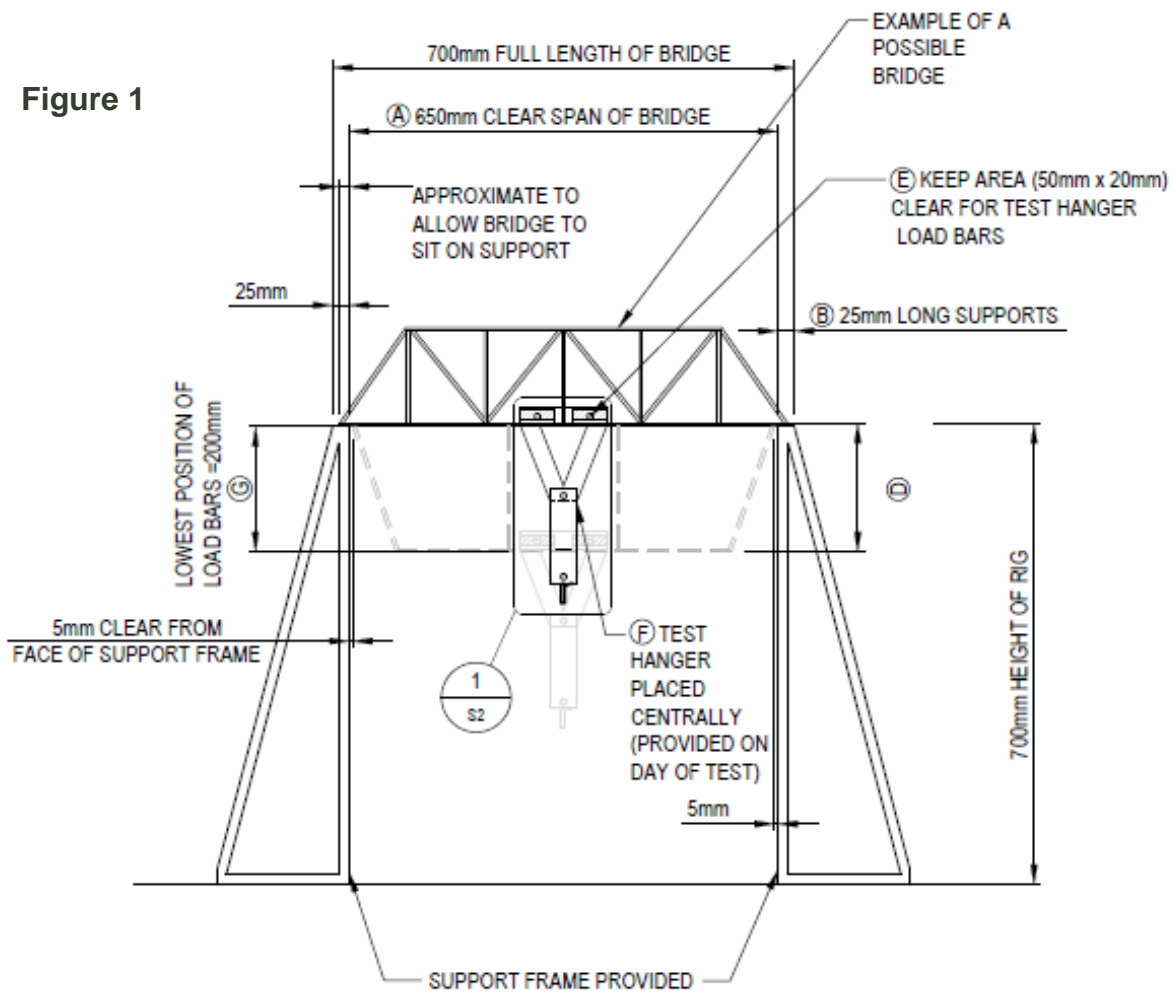
Your bridge will be required to allow a small vehicle to pass through or across it. It is not essential to have a deck; however, you must make provision for an 80mm wide roadway to be placed along your bridge with a **total clearance height of 40mm**. A 30mm wide x 35mm high vehicle will be passed along the bridge (refer to [Figure 4](#)). If the car cannot pass through or across the bridge, you may lose points for functionality.

**Important note:** The position and direction of the Bridge when the road and car is tested as per above, must be the same position and direction of how the bridge is placed on the testing rigs to be load tested.

### 3.1.7 Maximum weight

Your bridge's weight must not exceed 300 grams, including all decoration and materials used. Your bridge will be weighed on Judging Day, and bridges that exceed this weight may not be allowed to compete.

**Figure 1**

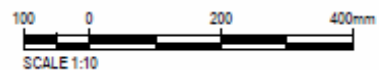


**ELEVATION**

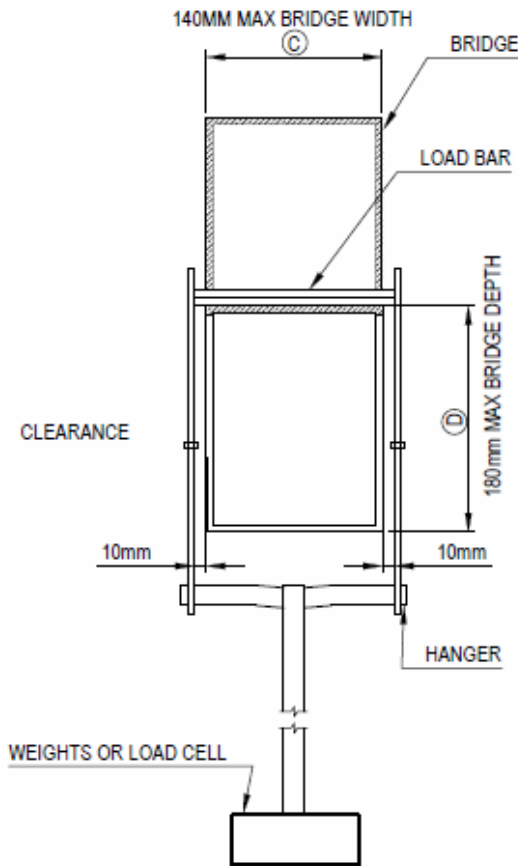
1:10

**NOTES:**

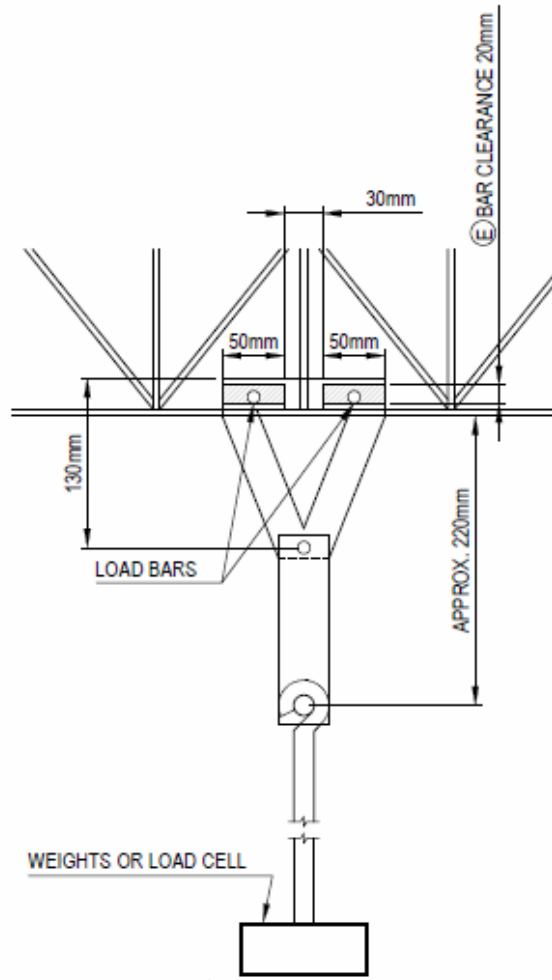
1. PLEASE ENSURE THAT TEST HANGER CAN BE FITTED ONTO BRIDGE IN ORDER FOR TESTING TO BE CARRIED OUT. REFER TO SKETCH S2 FOR TEST HANGER DETAILS.
2. PLEASE ENSURE YOUR BRIDGE COMPLIES WITH THE FOLLOWING REQUIREMENTS:
  - A) CLEAR SPAN IS 650MM
  - B) SUPPORTS TO BE 25MM LONG TO REST ON THE TEST FRAME
  - C) MAX BRIDGE WIDTH 140MM
  - D) A MAXIMUM BRIDGE DEPTH OF 180MM UNDER THE LOAD BARS IS PERMITTED
  - E) KEEP AREA SHOWN HATCHED (50mm x 20mm) CLEAR FOR LOAD BARS
  - F) TEST HANGER PLACED CENTRALLY (PROVIDED ON DAY OF TEST)
  - G) LOADS BARS MUST BE WITHIN 200mm OF SUPPORTS IF PLACED BELOW BRIDGE



**Figure 2**



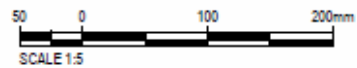
**SIDE VIEW OF BRIDGE & TESTING APPARATUS**  
1:5



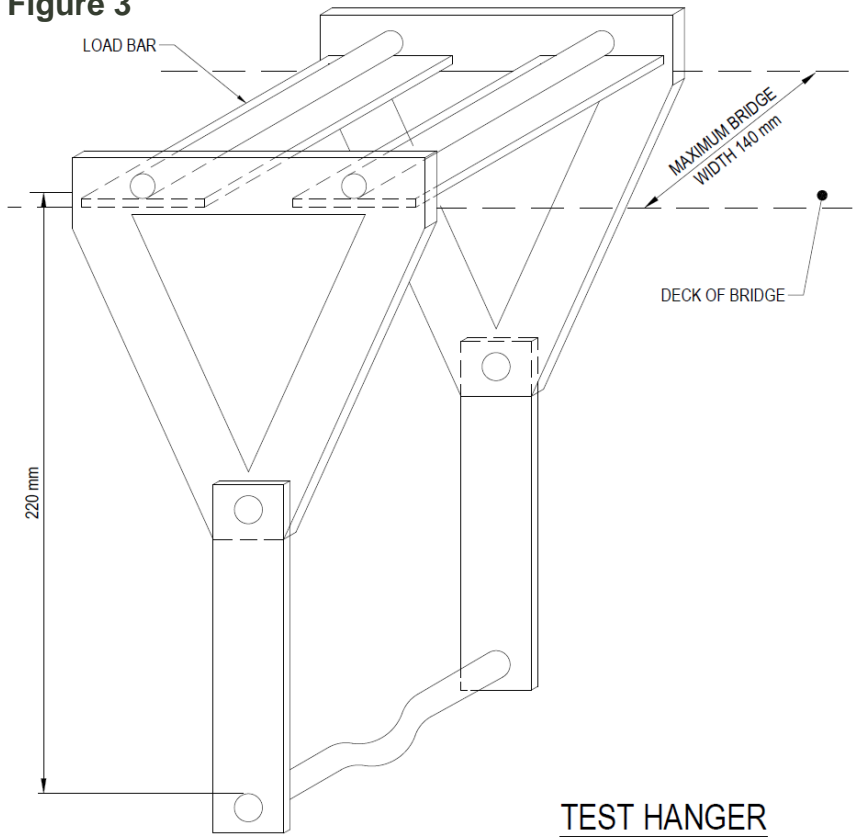
**TESTING APPARATUS**  
**WEIGHS ABOUT 3KG**  
1:5

**NOTES:**

- PLEASE ENSURE THAT THE HANGER AND APPARATUS ARE ABLE TO FIT ONTO THE BRIDGE

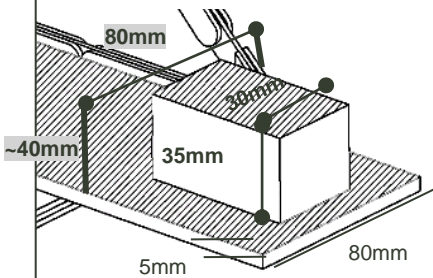


**Figure 3**



**Figure 4**

CAR & ROADWAY



## 4 Bridge building kit, tools and safety

### 4.1 Kit contents

Once your school has registered, Aurecon will send you a Bridge Building kit. The materials listed below are the only materials that can be used to make your bridge. The use of materials other than those supplied and paint for decoration (see section 4.4) will result in disqualification from the competition.

The kits will contain the following materials that may be used on your bridge:

- 12 balsa wood sticks (6.5mm x 6.5mm x 580mm)
- 12 balsa wood sticks (6.5mm x 6.5mm x 330mm)
- 1 tube of PVA glue (125ml) – the glue tube itself must not be used.
- 1 piece of 5m long string

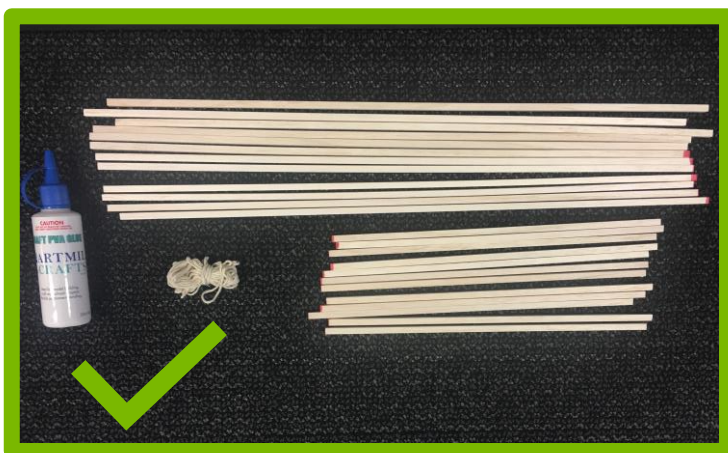
**You must not use these guidelines, or the packaging that the kit arrives in as part of your bridge. They are for reference and transport purposes only.**

#### Materials you can use

- Balsa wood (provided)
- PVA glue (provided) – not including tube
- String (provided)
- Colouring in marker pen, spray or water-based paint (schools to supply)

#### Materials you cannot use

- Tube
- Tube caps
- Guidelines (for reference only)
- Acrylic paint or additional glue



### 4.2 Digital tools for Digital Award

To compete for the Digital Award, teams must email an [AutoCAD](#) (.dwg), [SketchUp Make](#) or [SketchUp Free](#) (.skp) file of the bridge's wireframe to [bridgebuildingcompetition@arecongroup.com](mailto:bridgebuildingcompetition@arecongroup.com) by 11.59pm Monday 5 August 2019. These programmes are free for schools to use. AutoCAD and SketchUp Make are desktop programs that can be downloaded to your computer, and SketchUp Free is based on a web browser.

Click to view and/or download software for:

- [AutoCAD](#)
- [SketchUp Make](#)
- [SketchUp Free](#)

**Important note on Sketchup Pro:** All programmes are free for all educators and schools to use and do not require a license. As part of downloading SketchUp Make you may receive a free trial of SketchUp Pro for 30 days. You may wish to design your bridge using the SketchUp Pro trial, however no points will be given for creating your design to scale. Teams must not under any circumstances use sketches from the SketchUp 3D warehouse.

For more information, and to view a tutorial video on how to use AutoCAD and SketchUp, visit the [Aurecon Bridge Building Competition website](#).

### 4.3 Extra equipment

Aurecon recommends using the following extra equipment to construct your bridge:

- Safety goggles and gloves
- A printed copy of your digital bridge design you created in AutoCAD or SketchUp
- Pencils and paper for planning and drawing bridge before it is constructed
- A tape measure and a ruler
- A small hacksaw or Stanley knife for cutting the balsa wood
- Clothes pegs or bulldog clips for temporarily holding the balsa wood together whilst glue is drying
- Sandpaper for finishing edges for a better build quality



### 4.4 Decorating your bridge

Colouring in marker pen, spray or water-based paint can be used to decorate your bridge. Acrylic paints, additional glue, or surface finishing coatings are not permitted. Please note to always apply coating in a well-ventilated area.

**Important note:** Please ensure that any decorations used do not result in your bridge exceeding a weight of 300 grams.

### 4.5 Safety precautions

Safety is very important at Aurecon. We recommend the following steps to ensure your safety:

- All construction and decoration work must be supervised by a teacher at all times



- Wear safety goggles and gloves while creating your bridge
- Ensure workplace is well ventilated at all times, especially while gluing and decorating
- When working with sharp tools, cut on a clean, flat, and stable surface
- Read and carefully observe all glue instructions included in your kit
- Protect the surfaces you will be working on from glue and accidental cutting

## 5 Judging and testing

### 5.1 Judging

On Judging Day, your team(s) will be called before a panel of judges consisting of Aurecon engineers and/or guest judges who will engage in discussion with the team about the approaches and techniques used in your bridge design. The total formula of the design score is:

$$\text{Design Score (20)} = \text{Workmanship} + \text{Innovation} + \text{Aesthetics} + \text{Functionality}$$

The judges will assess your bridges in the following categories which each make up 5 points towards the total judges' score:

#### 5.1.1 Workmanship (5 pts)

- Joints with good contact between *members*
- Robust feel
- Compliance with dimension requirements
- Member size correspond *to force flow path*

#### 5.1.2 Innovation (5 pts)

- Structural form
- Efficiency in *force flow path*
- Creative techniques at joints
- Use of building techniques (e.g. *post-tensioning* of string, *beam* types, etc.)

#### 5.1.3 Aesthetics (5 pts)

- Visual appeal
- Proportion
- Neat finish

#### 5.1.4 Functionality (5 pts)

- Ability to support a roadway
- Ability to pass traffic across the bridge
- Smoothness of traffic flow along the roadway

**Important note:** As per section [3.1.6 above](#), the position and direction of the bridge when the road and car is tested, must be the same position and direction of how the bridge is placed on the testing rigs to be load tested.

### 5.2 Testing

Your physical bridge will be tested in the bridge testing zone at the Judging Day events. Bridges are tested by progressively increasing the load on the hanger attached to the bridge.

Your bridge is considered to have failed if any member or joint breaks or the bridge fails to carry any additional load. The load will be recorded in the judging spreadsheet.

On the day, you will be required to wear safety goggles provided by Aurecon. Aurecon engineers will be conducting the testing.

**Important note:** While we take all steps to test all the bridges on Judging Day, if a bridge is non-compliant with the rules of this competition in any way, it cannot be eligible for any of the prizes. Please check with the specifications outlined in [section 3.1](#) to ensure it can be tested. The most common mistake made by teams is constructing a bridge that is not long enough to fit on the testing rigs. If this happens, we are unable to test the bridge at all.

### 5.2.1 Digital component testing

Expert engineers from Aurecon will pick out the three best (per location) digital bridge AutoCAD or SketchUp wireframe designs that have been submitted to [bridgebuildingcompetition@aurecongroup.com](mailto:bridgebuildingcompetition@aurecongroup.com) by 11.59pm on Monday 5 August 2019. The Aurecon engineers

After the bridge wireframes have been submitted, Aurecon engineers will select the three best bridge wireframe designs per location and will virtually test these using bridge analysis programmes to determine which bridge supports the highest load.

The top three digitally designed bridges will be showcased and virtually tested on a projector at the Judging Days events. The digital testing of the projects will be compared and contrasted with the testing of the physical bridge on the rig. Then, the strongest digitally designed bridge will be awarded the Digital Award prize.

The top three digitally designed and consequent virtual testing results will be kept confidential until Judging Day. The winner of the Digital Award will be announced at prize giving at the end of the day.

## 6 Scoring

Each bridge will receive an overall score, determined by the formula below:

$$\text{Total score} = \text{Design Score (20)} + \frac{\text{mass supported by bridge (kg)}}{\text{self weight of bridge (g)}} \times 30$$

The Design Score is the total of the judges' score (20 points) as per [section 5.1](#). This is added to the efficiency score, which is determined by the ratio between the mass supported by the bridge and the weight of the bridge itself.

### 6.1 Award categories

Based on your team's bridge design, your team may take home one of the following award titles. These will be awarded on the day of the event based on your bridges performance.

#### 6.1.1 All-Rounder Award

The 'All-Rounder Award' is won by the team with the highest combined score (strength-to-weight and judges score) as detailed above. Winners will receive:

- \$1000 cash prize to school
- \$100 gift vouchers to each student in the team

#### 6.1.2 Efficiency Award

The efficiency award is given to the team whose bridge design has the best strength-to-weight ratio, that is, the maximum amount of weight it can carry/support without collapsing compared to the weight of the structure. Winners will receive:

- \$500 cash prize to school
- \$50 gift vouchers to each student in the team

### 6.1.3 Strength Award

The 'Strength Award' is offered to the team whose bridges reach the maximum mass supported by the bridge recorded on the day. Winners will receive:

- \$500 cash prize to school
- \$50 gift vouchers to each student in the team

### 6.1.4 Innovation Award

The 'Innovation Award' will be assigned by the judging panel on the day of the competition. This is a combination of creativity and innovation and awarded to the team's bridge that stands out from the crowd. Winners will receive:

- \$500 cash prize to school
- \$50 gift vouchers to each student in the team

### 6.1.5 Digital Award

Teams are encouraged to submit the digital wireframe design of their bridge drafted in AutoCAD, SketchUp Make or SketchUp Free to [bridgebuildingcompetition@arecongroup.com](mailto:bridgebuildingcompetition@arecongroup.com) by 11.59pm on Monday 5 August 2019. After the bridge wireframes have been submitted, Aurecon will select the three best bridge wireframe designs per location and will virtually test these using bridge analysis programmes to determine which bridge supports the highest load.

The winning students of the Digital Award will receive:

- \$50 gift vouchers to each student in the team

## 7 Construction tips

To ensure you have the best chance of success, we recommend the following:

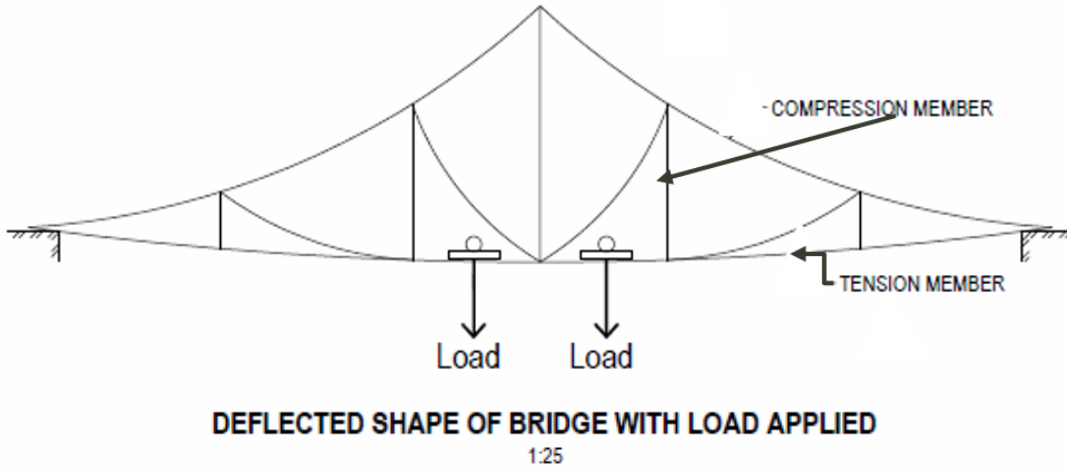
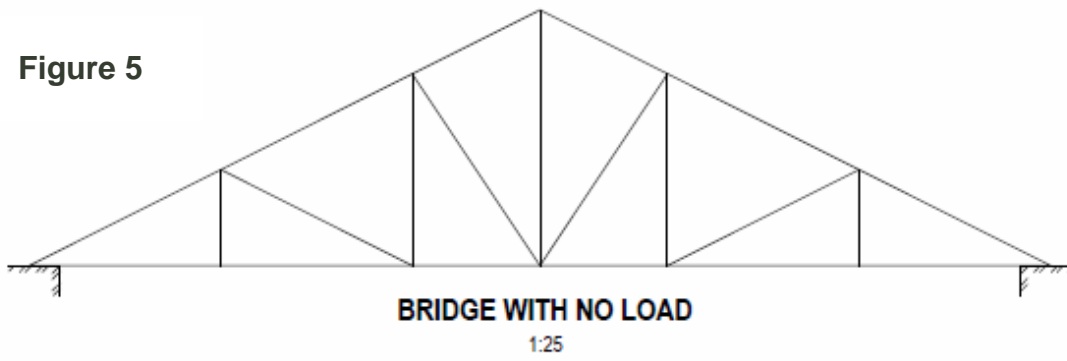
- To improve the strength of your bridge, and also make it easier to plan and design construction, try designing a wireframe of your bridge first using AutoCAD, SketchUp Make or SketchUp Free. This will ensure you don't run out of materials and help you plan the structure of your bridge before you build it
- Pay attention to the *joints* between the timber elements. This is critical to the bridge achieving its capacity. Bridges most often fail here because of lack of glue or inadequate contact between the two surfaces
- Think about the forces in each *member*. Will it be in *tension* or *compression*? In other words, are the *members* being stretched or crushed? Picture how the bridge will *deflect* (refer to [Figure 5](#)) – this will help you visualise the forces in the *members*. Long *members* in *compression* have a tendency to *buckle*. A *member* that is long will *buckle* and therefore fail more easily than a short *member* of the same cross section

You can try this out with a ruler. Carefully push on both ends of a plastic 30cm ruler and see how it bends as you apply force. Now get a friend to gently support the centre of the ruler with a finger on both sides, and again carefully push on the ends of the ruler. Notice how the ruler resists more force. If you have long

*compression members* in your bridge, consider reducing their unsupported lengths by connecting them to *cross members* or *bracing* (refer to [Figure 6](#)). A *member* that is in *tension* will most likely fail at its *joints*

- Think about where the maximum forces are going to be applied, and how this might affect your construction method. Remember all of the pieces provided are shorter than the distance the bridge needs to *span*
- Think about the most efficient use of the materials supplied. The aim is to use all of the materials provided in your bridge design, except for these guidelines and the tube of glue itself
- If you use the string to supplement the strength of balsa wood *tension members*, try *tensioning* the string. *Untensioned* string adds no benefit. You can *tension* the string by gently applying a *compression* force to your *tension members* while fixing the string in place until the glue dries. Remember to only apply a force to your *members* once they have already been glued in position. Failure at supports is common due to the *shear forces* present. Your design needs particular attention in these areas to make them strong and stable. The ability to resist *shear forces* depends on the amount of material used. Two pieces of balsa wood will have twice the strength to resist *shear force* than a single piece
- Be as accurate as possible keeping symmetry about the *longitudinal axis* of the bridge (parallel to the direction of the *span*). This will help the bridge load evenly, and prevent twisting of the bridge as well as assisting in maintaining stability
- Don't forget to take visual appeal, workmanship and creativity into account when designing and constructing your bridge— points will be awarded for these three categories.
- Have a good look at the bridge ideas presented in Figures 7 – 10 as examples of design

Figure 5



**TENSION**  
(IS LIKELY TO FAIL AT JOINT)



**COMPRESSION**  
(WILL BUCKLE MORE EASILY IF MEMBER IS TOO LONG)

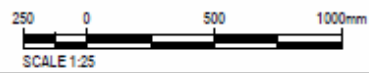
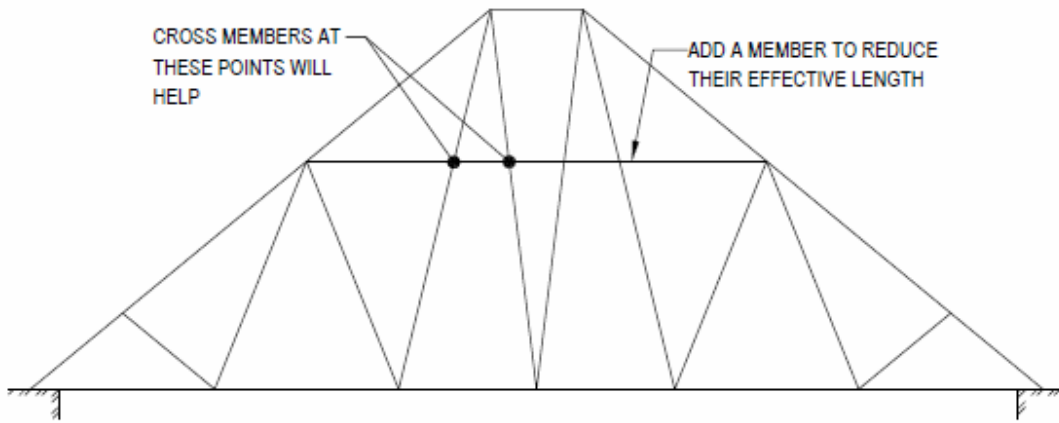
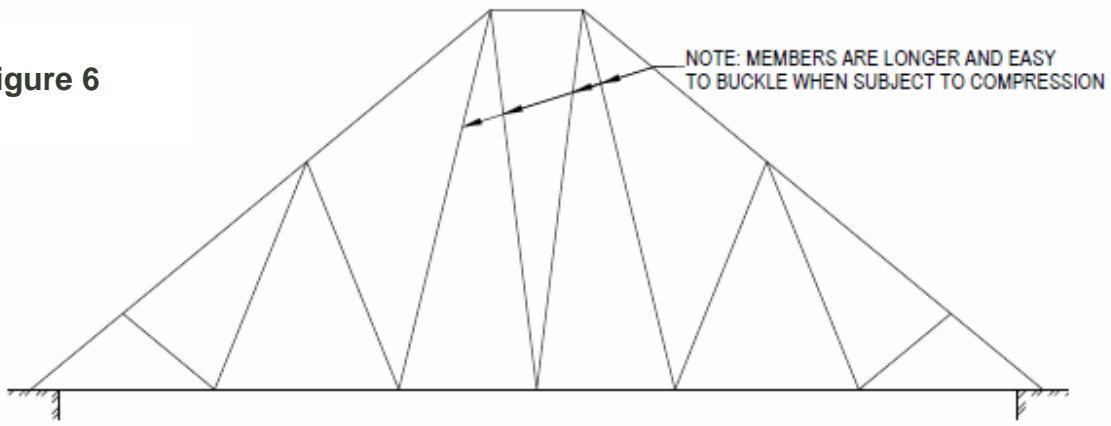


Figure 6



RULER (LAID FLAT)

USED TO ILLUSTRATE A SHALLOW BRIDGE ie:



BENDS VERY EASILY

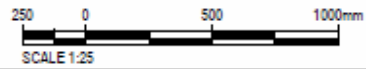


RULER (ON SIDE)

USED TO ILLUSTRATE A DEEP BRIDGE ie:

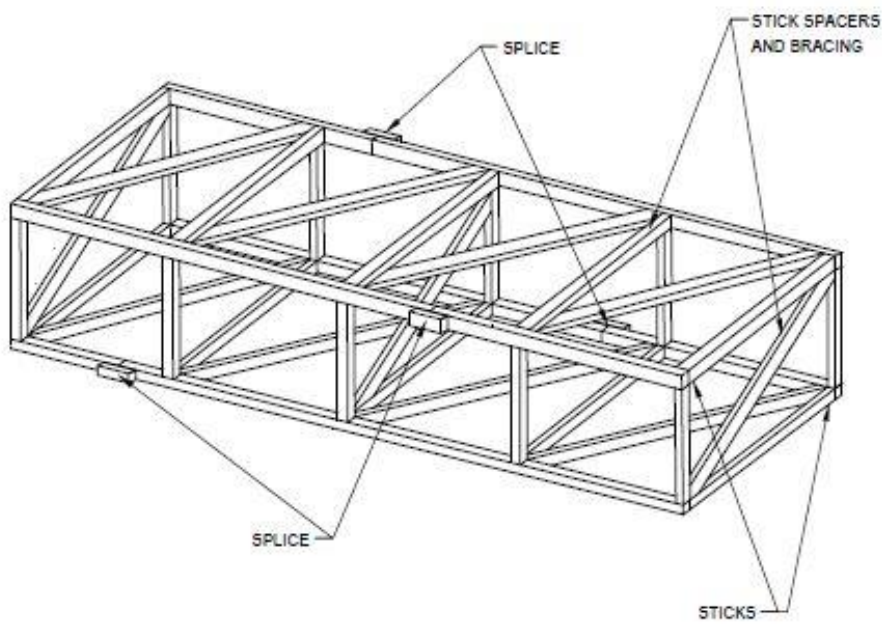
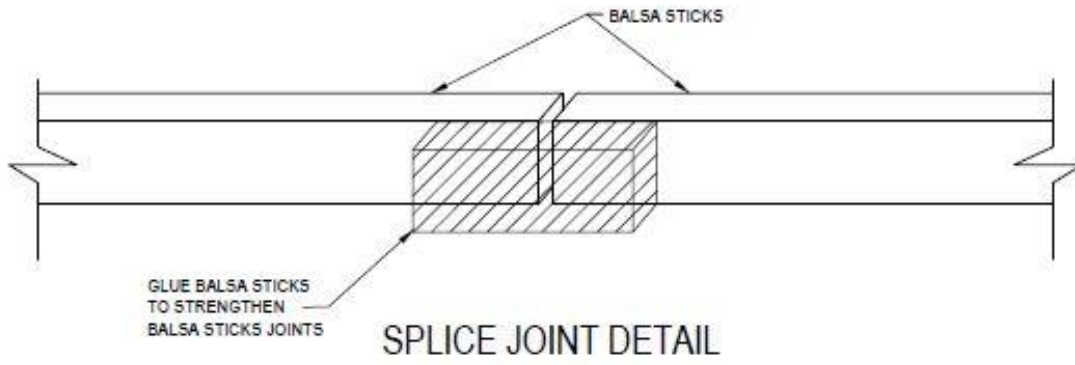


DIFFICULT TO BEND



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Figure 7



GIRDER BRIDGE

**Figure 8**

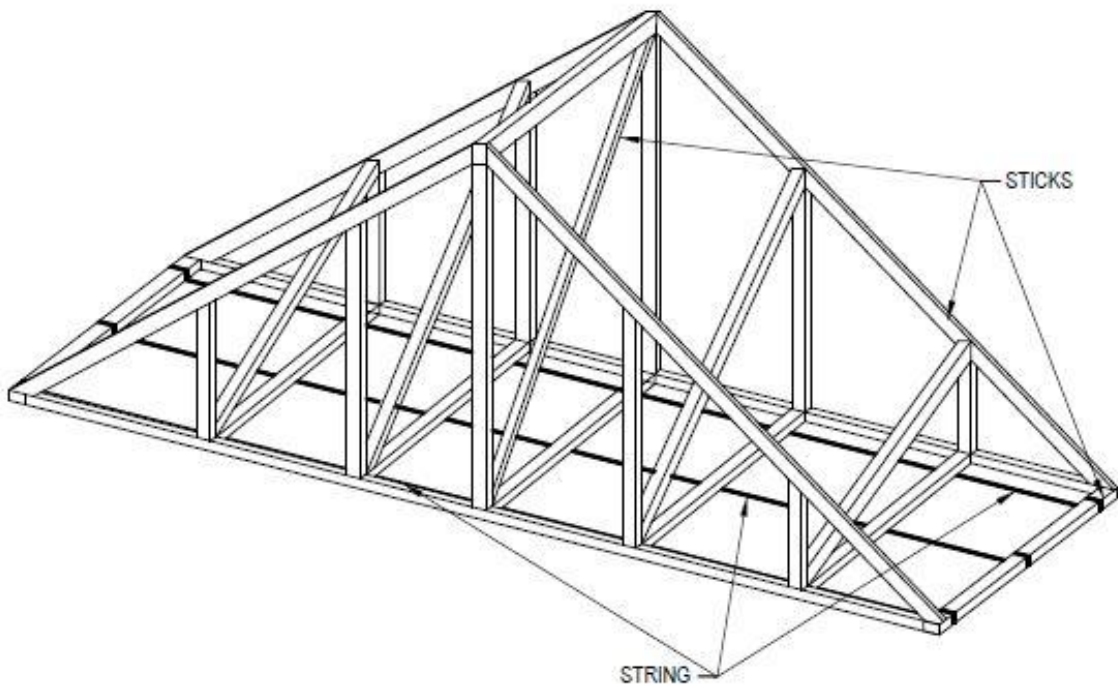




Figure 9

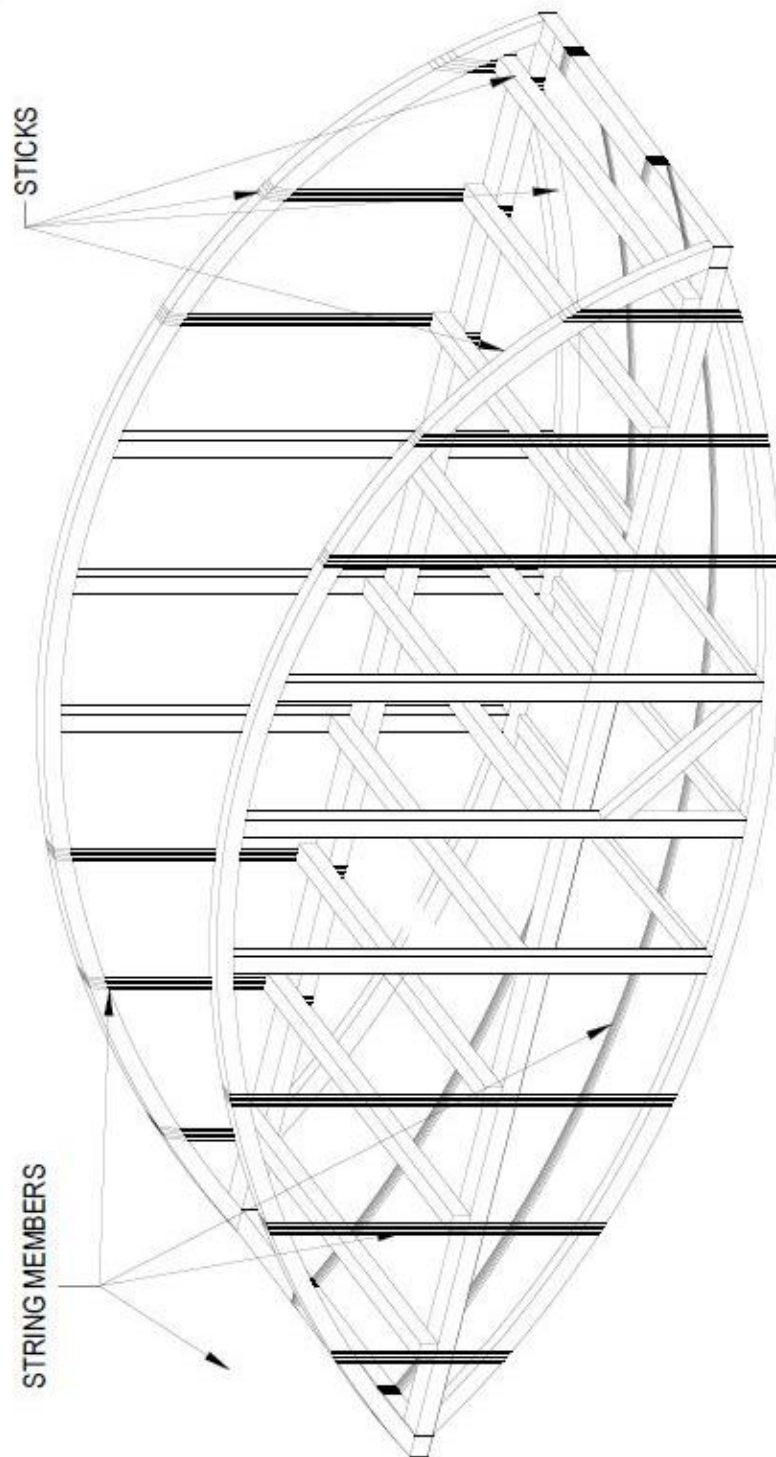
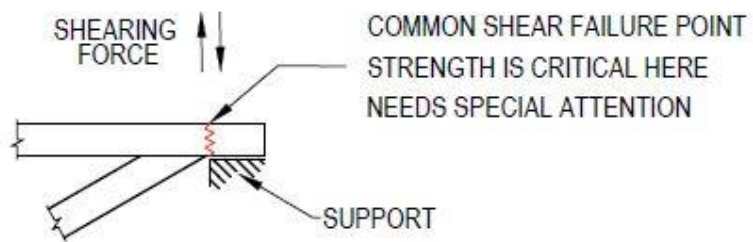
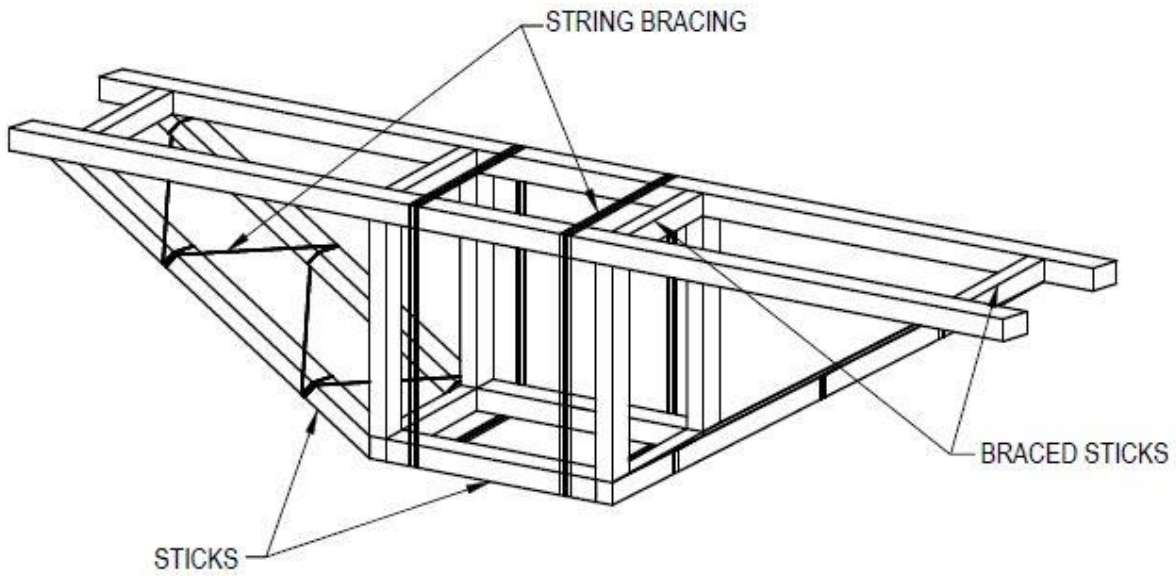


Figure 10



## 8 Glossary

The following terms are referenced in the guidelines:

Word	Definition
1. <b>Beam</b>	A member that resists loads by bending.
2. <b>Bracing</b>	A structural member used to stabilise or stiffen a framework.
3. <b>Buckle</b>	The bending, warping, or collapse under a force. It occurs when compression overcomes an object's ability to endure that force.
4. <b>Capacity</b>	The maximum amount that something can contain/take.
5. <b>Compression</b>	Compression is a force which squeezes objects together.
6. <b>Cross-Section</b>	A 2D perception of the internal arrangement of a 3D object .
7. <b>Deflection</b>	The movemenet of a structure or structural part as a result of stress.
8. <b>Force Flow Path</b>	The path an external force takes to reach the supports through your structure.
9. <b>Joints</b>	A connection point, in this instance, the joint is at the glue to timber member interface.
10. <b>Lateral support</b>	A type of support to help prevent sideways movement.
11. <b>Member</b>	An element that forms part of any structure or bridge, such as a beam, bracing or a support.
12. <b>Shear</b>	A force which slips two surfaces away from each other.
13. <b>Span</b>	The clear distance between the support points
14. <b>Tension</b>	Tension is the force that stretches or pulls objects apart.