BUILDING A STRAW BRIDGE

Engineers Australia

EngQuest, an initiative of Engineers Australia, provides an exciting, non-competitive way for students to participate in free, fun and educational engineering activities involving mathematics, science and technology.

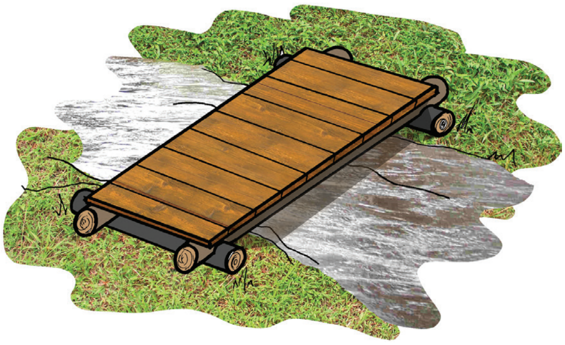
Below is a sample of one of the middle school activities in the program. To register for EngQuest and receive your teacher's pack, go to www.engquest.org.au. It's free.

We take bridges for granted in our daily lives. We regularly cross bridges of various types and lengths without even thinking about it. But imagine how much harder travel would have been for the early explorers and settlers of Australia without bridges, particularly when they needed to cross larger streams and rivers.

When explorers Hume and Hovell travelled through New South Wales and Victoria towards South Australia in 1824, they improvised bridges with tarpaulins wrapped first around a cart, and later around a structure made of poles, in order to ferry their party and its supplies across the Murrumbidgee and Murray Rivers. They were severely hampered by the lack of bridges.

The early history of bridges is not recorded, but it is likely they would have been fallen trees across streams, which people walked over. Later, simple rope or vine bridges would have allowed people to climb across, and from this would have come more complex rope bridges made up of many ropes fixed together, eventually with decking which made it easier for people to walk across. However rope bridges are not long-lasting, and not suitable for heavier vehicular traffic.

The next technological development in bridge design was the stone arch bridge. These date from Roman times, around two thousand years ago. For their structural strength they depend on the shape of the arch. In a simple arch bridge, the weight of the bridge and the load crossing it is transmitted through the arch to the walls (the banks of the stream or river), so the arch does not collapse. In order to cross a wider span, numerous arches could be linked together, with the ends of each arch



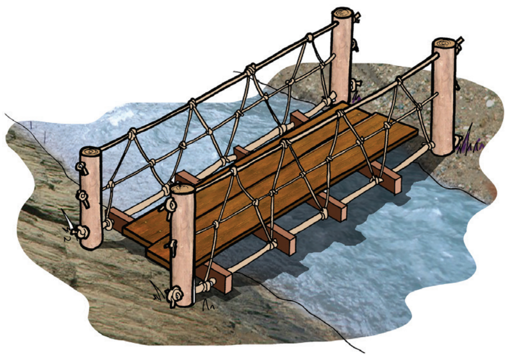
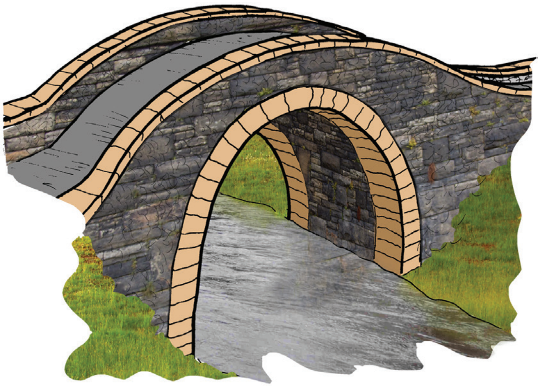


Figure 1 (left): Log bridge.

Figure 2 (right): Rope bridge.



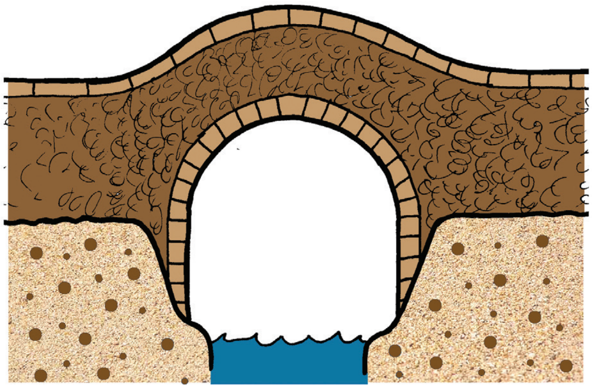


Figure 3 (left): Stone bridge.

Figure 4 (right): Load distribution of stone bridge.

supported by a post or pillar. Many very large and long bridges and viaducts were constructed in this way in Roman times, with some surviving even to this day.

Stone arch bridges continued to be built for many centuries. There are some classic examples of these still surviving from early Australian convict times, particularly in Tasmania. However, the emergence of structural steel as a building material during the industrial age allowed the design and construction of bridges on a scale never before contemplated.

The early citizens of Sydney and San Francisco could never have imagined their harbours would be spanned by huge steel bridges. Even some eighty years after its construction, the Sydney Harbour Bridge remains a great Australian icon and engineering achievement.

There are numerous variations in the design of such large bridges, including cable suspension bridges, steel arch bridges, cantilever bridges, and truss bridges.

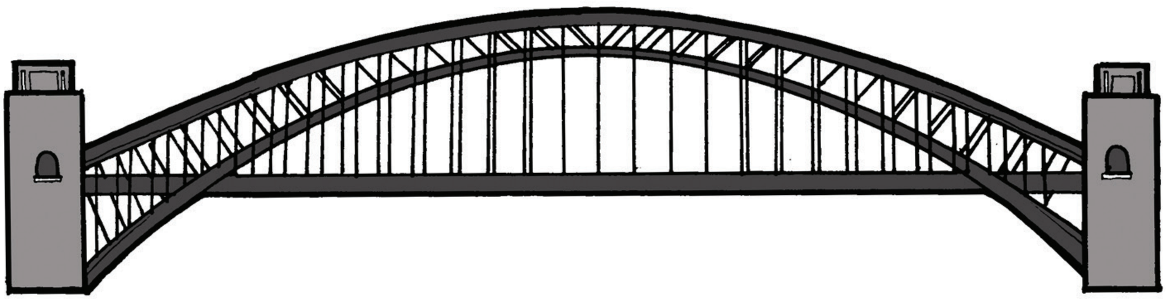


Figure 5: Sydney Harbour Bridge.

ACTIVITY: BUILDING A STRAW BRIDGE

BROAD LEARNING OUTCOMES

Students will:

- work as part of a team, each playing a particular role;
- design, make, test and critique a straw bridge;
- gain hands-on experience in design and construction;
- discover how to best record all observations, planned modifications and observed results in a journal; and
- build on their speaking and listening skills by sharing their straw bridges.

THE PROJECT

The project is for a team of students (groups of two or three are ideal) to design and construct a model of a single-span bridge, using plastic drinking straws as the building material.

All steps of the design, construction, testing and critiquing stages should be recorded by students in a journal. Students may like to include labelled diagrams, tables, graphs, photos etc.

It is important for student learning that opportunities are provided for cooperative learning, which is a significant aspect of engineering and scientific work.

This activity is structured with the intention that students work in teams using a collaborative approach. It is recommended that each team member is assigned a particular role and that roles are rotated regularly.

RESEARCH

To get started, students can conduct research on the different designs and shapes of bridges. These could include truss, arch, cantilever, post, suspension and cable-stayed designs. A web search on 'bridge designs' will produce a number of sites with information on this topic.

There are many famous world bridges of various designs, such as the Sydney Harbour Bridge, the Golden Gate Bridge, the Firth of Forth Bridge, Tower Bridge and so on. These could provide inspiration and direction for the students' designs.

DESIGN

Having explored various bridge designs, the teams can select their bridge type. The bridge needs to span a distance of 40 cm and be approximately 10 cm wide. There should be no supporting pillars to the ground in between the ends of the span. It must be strong enough to support a suitable load placed on the middle of the completed structure. The load should be selected so that all reasonably well-designed structures pass the test.

Have students sketch their plans at half size, which will allow the drawings to be made on a sheet of A4 paper.

CONSTRUCTION

Having designed the bridge, the next stage is for the students to construct their bridge from the materials supplied.

Each team will need to construct the gorge over which to build the bridge. The gorge needs to be about 40 cm wide, and could be made with two stacks of books or bricks of even height.

You will need.

- Plastic drinking straws (50 per bridge as a rough guide), each approximately 24 cm long.
- Household pins to fasten the straws together (Blu-Tack™ or thin strips of masking tape could also be used).
- A strip of thin cardboard or paper approximately 45 cm long and 10 cm wide to act as the bridge decking. This should not form part of the structural strength of the bridge.
- Scissors to cut the straws to appropriate lengths.
- A load to test the bridge with (a can of food or a book will be suitable).

CONSTRUCTION COSTS

The designs of structures such as bridges should be as cost effective as possible. One way of comparing the 'costs' of the different designs is for the students to calculate the cost of their structure using a formula such as the following:

For each whole straw used	$10,000
For each pin (or tape join)	$2,000
For each cut or bend in a straw	$1,000
Total	$ _____

Part of the challenge could be to construct the least expensive bridge that will support the required load.

TESTING

Now for the fun bit. Set the bridges up across the gorge and gently place the load on the structure to see if the design will support the weight.

CRITIQUE

It is likely the students will see a need to modify their designs in order to make improvements either during the construction stage, when the design is tested, or both. They should be given opportunities to analyse their work, come up with suggested improvements, and to test these.

ASSESSING THE PROJECTS

After completing the construction and testing of their bridges, students should assess the success of their project—which aspects worked, what they learned whilst doing the project, what else they would like to learn, and which aspects they would do differently.

Some of the specific aspects to explore are listed below.

- Which designs were most successful? Why?
- Which shapes included in the designs appeared to be strongest? (This might lead to exploring triangulation and bracing structures.)
- Are there any factors that weakened the structural units (the straws), or created weak points in the structure. What were they?
- Which parts of the structures were affected by 'pushing together' forces (compression), and which parts were affected by 'pulling apart' forces (tension)? Did the structural materials (the straws) have more strength under compression or tension? How could you test this?

KEEP SAFE!

Allow plenty of time to discuss the safety precautions that are essential when assembling and testing straw bridges. As a class, discuss how students can keep themselves and others safe. All students should agree with these rules before starting and the safety precautions and guidelines should always be observed.

LINKS TO THE AUSTRALIAN CURRICULUM

SCIENCE

Science Inquiry Skills

As students will be involved in conducting experiments during this project, all areas of this strand will be addressed. Students will question and predict, plan and conduct, process and analyse data, evaluate and communicate.

MATHEMATICS

Number and Algebra

Number and place value: Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers.

- Applying strategies already developed for solving problems involving small numbers to those involving large numbers.
- Applying a range of strategies to solve realistic problems and commenting on the efficiency of different strategies.