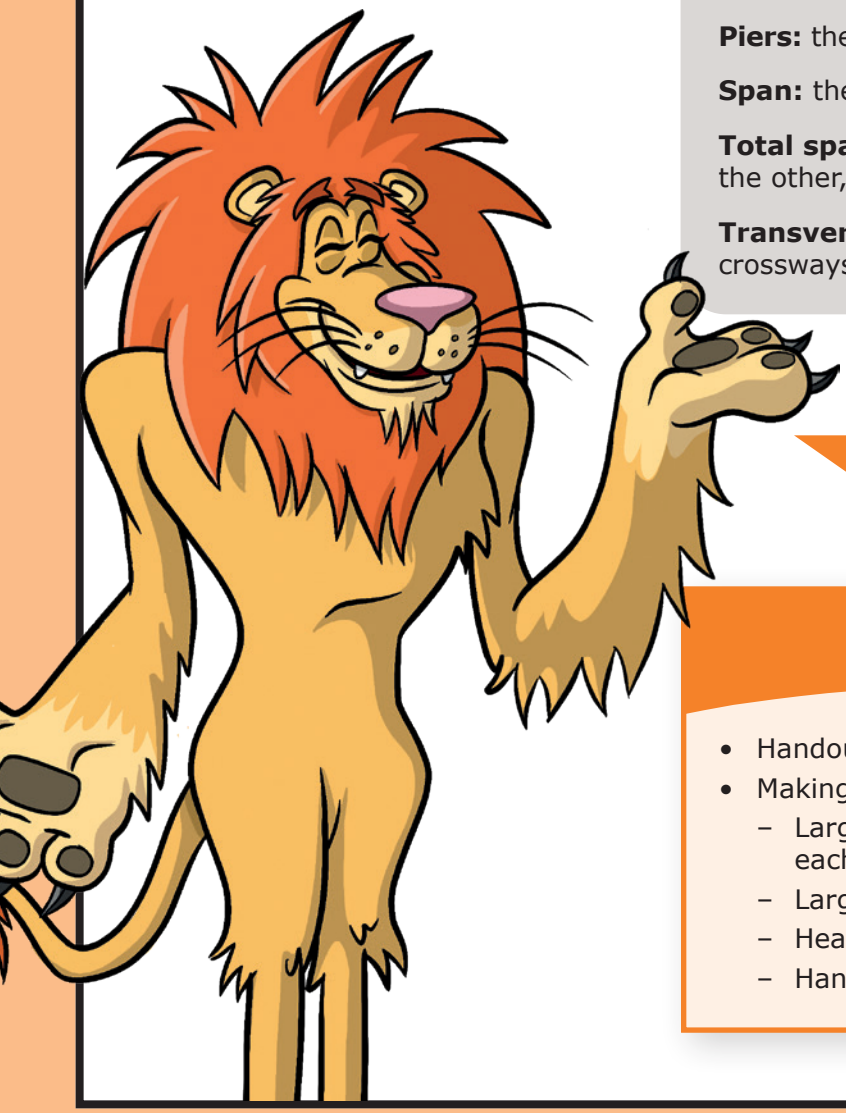
Chapter Bi: Beam Bridges – The First Bridge

AIMS & OBJECTIVES

- To learn key terms for beam bridges
- To understand how bridges developed

CONTEXT

The earliest form of bridge was a beam bridge, constructed from a log or wooden plank. The word bridge is itself derived from an ancient word for log or beam.



LANGUAGE OF BRIDGES:

Abutment: the structure that the ends of the bridge rest on and can be anchored by.

Beam: the simplest form of bridge, consisting of a single span resting on abutments.

Corrugated: folded into small furrows or ridges.

Deck: the main surface of the bridge, the traffic crosses here.

Hinge: a fold that allows movement to swing open and closed from that point.

Parapet: a low wall or railing alongside the edge of the bridge deck to protect traffic from falling off.

Piers: the upright columns that support the bridge.

Span: the distance between bridge supports.

Total span: the full distance, from one side to the other, the bridge covers.

Transverse: something at right angles, or crossways, to something else.

We are going to think more about simple bridges and why they're so important...

You will need...

- Handout: *Beam bridge terminology*
- Making bridges stronger challenge, per group:
  - Large books to build two 30cm high piles for each group of learners (optional)
  - Large cardboard sheets or old boxes
  - Heavy weights, such as dumbbell weights
  - Handout: *Beam bridge record sheet*

Something to Try:

Anyone who has ever placed a log over a stream so they didn't get their feet wet has built a bridge. Possibly the earliest structure ever built by humans is a bridge – early humans probably used the simplest form of bridge to cross narrow streams and gorges long before they built houses or settlements. The simplest and oldest type of bridge is the beam bridge.

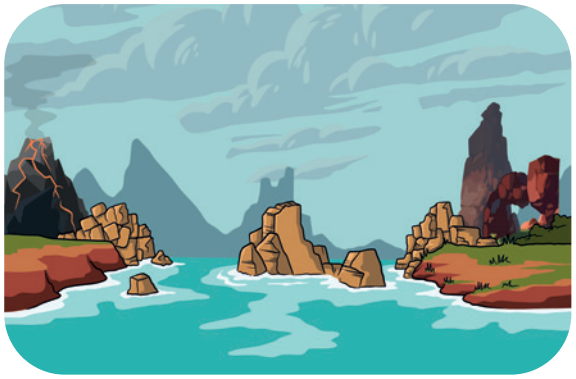
- The caveman puts a log over a stream – he has built a bridge but it is wobbly and precarious.

- He turns the log into a plank (i.e. beam) – it is more stable and easier to walk over but it sinks into the mud in wet weather.

- He piles up stones under the ends of his beam – he has made abutments. His bridge is steadier but now it is much higher up and can be scary to cross in the wind.

He makes simple parapet rails out of sticks and vines.

Now he knows how to build a good, strong bridge but when he wants to cross a wider river the trees are too short. So he piles up stones in the middle of the river to make a pier.



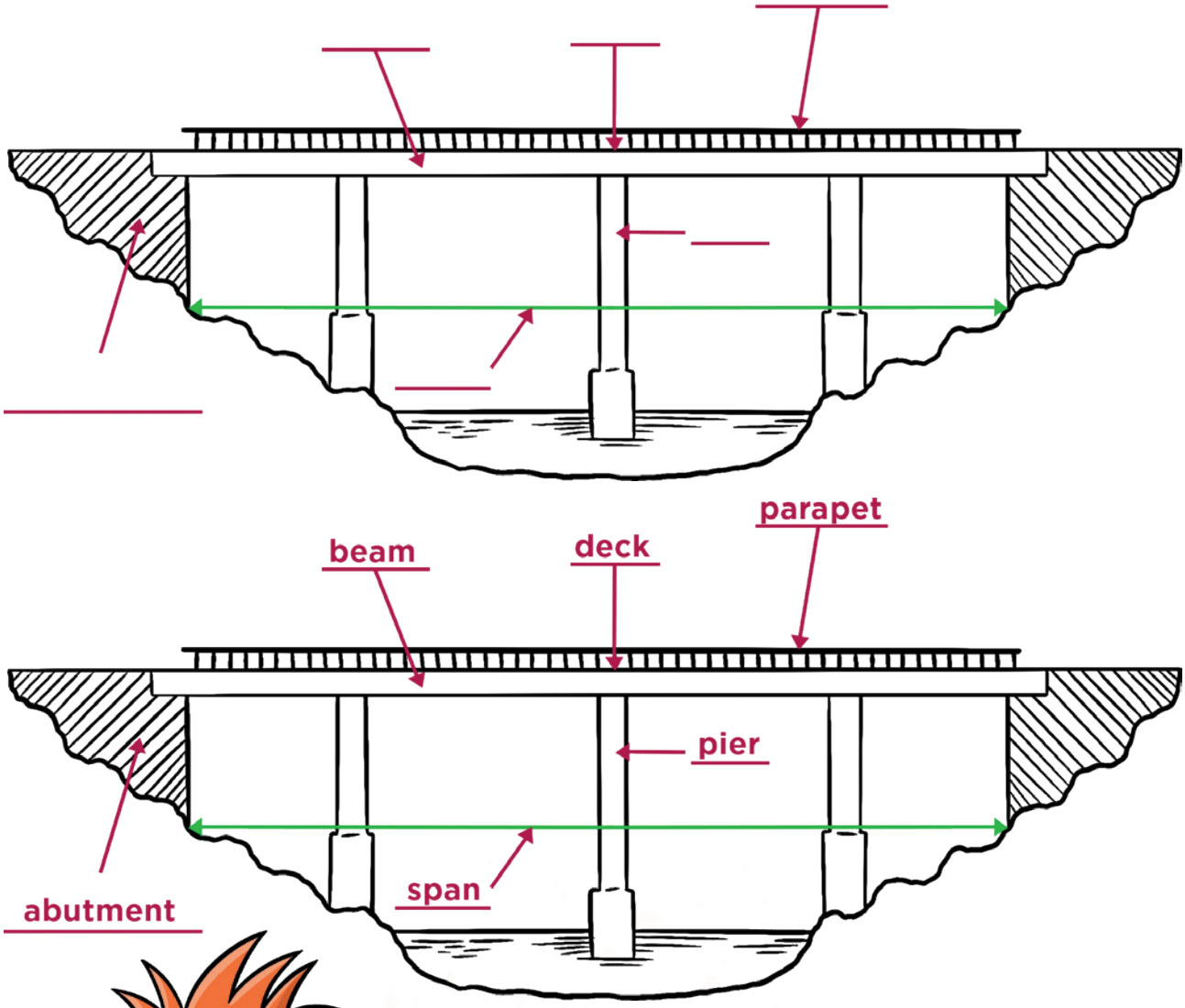
By adding a beam on each side he has doubled the length of his bridge.

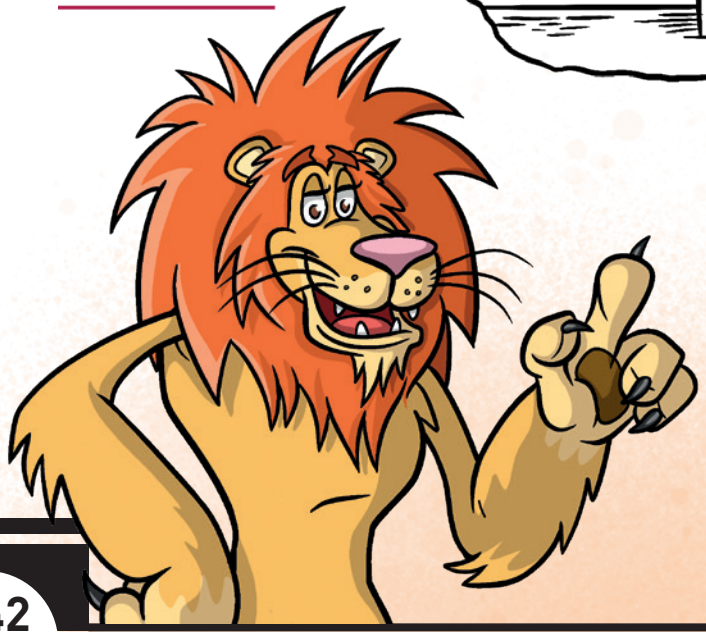
One of the longest beam bridge spans in the world – and currently the longest in the Southern Hemisphere – is 300 metres and is part of the Rio-Niteroi Bridge in Brazil.

Photo by Halley Pacheco de Oliveira via Wikimedia

LABELLING THE BEAM BRIDGE

Give learners a copy of the *Beam bridge terminology* handout. Get learners to identify the different parts of the beam bridge.



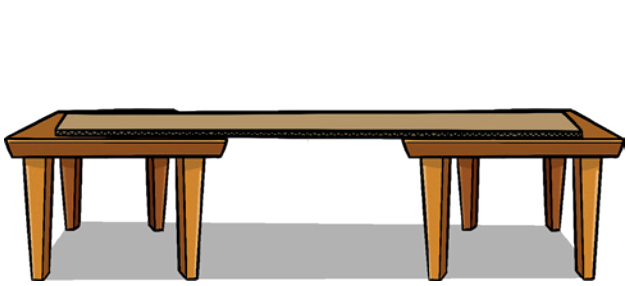


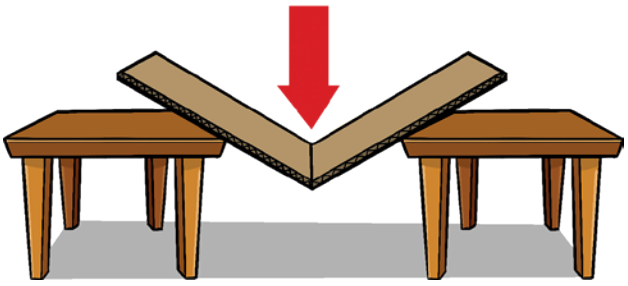
Challenge Time!

Place two tables or desks 40 centimetres apart, and place a sheet of A3 card across the gap. This has made a simple beam bridge. This cardboard bridge is strong enough to hold up its own weight. In a real bridge the weight of the bridge is called the dead load. This is because once the bridge is built the dead load stays the same and does not move about.

Now walk your fingers across the cardboard bridge leaning hard enough to make the bridge bend and even collapse. That represents the live load. On a real bridge this might be the traffic or a train going across. It could also be the wind blowing across the bridge, or snow falling. The live load moves and changes all the time.

A bridge engineer needs to work out what the dead load and live load will be and make sure the bridge is strong enough to carry both of those loads.





TESTING BEAM BRIDGES

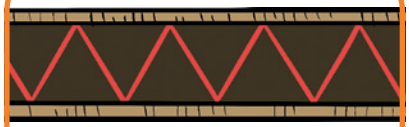
There is an illustrated step-by-step guide on the following pages.

Brief the learners on the safety rules for this activity:

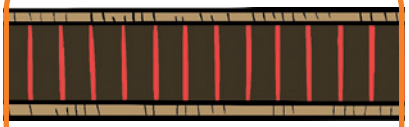
- Weights must be added one at a time, slowly and carefully.
- Make sure each weight is securely balanced before the next one is added.
- The weights must be removed one at a time and not allowed to fall.
- Care should be taken to keep fingers and feet clear of the pile of weights.
- For each small group, set up desks or tables with a gap of about 50 to 60 centimetres between the abutments.

For safety reasons, it may be preferable to use a pile of large books or blocks of solid wall insulation on a carpeted floor to reduce the risk of the heavy weights falling from any height. If this option is used, make sure there is a clearance of about 30 centimetres under the bridge to ensure the experiment works properly.

Taking each cardboard beam in turn, discuss the way they are described and explain the meaning of the terms used. Discuss the terms corrugated, transverse and longitudinal.



Corrugated: folded into small furrows or ridges



Transverse: something at right angles, or crossways, to something else

Longitudinal: running lengthwise, along the material, not across it

Add weights until the beam bridge fails by collapsing or bending so much in the middle it cannot carry any more weight and almost touches the river beneath the bridge. Record on the *Beam bridge record sheet* handout the final weight each beam carried just before it failed.

Encourage the learners to observe how the bridge failed. Did it just keep bending more and more? Did it fail by creating a straight line in the cardboard – engineers might describe this as a hinge forming – compare it to the hinge on the classroom door. What condition is the beam in after failure? Does it spring back to its original shape so that it could be used again? Or has it failed completely so that it could not carry so much weight again?

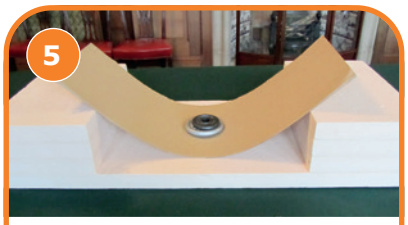
STEP-BY-STEP INSTRUCTIONS FOR TESTING BEAM BRIDGES

Create the abutments using blocks of wall insulation, or a pile of large books, on a carpeted floor.

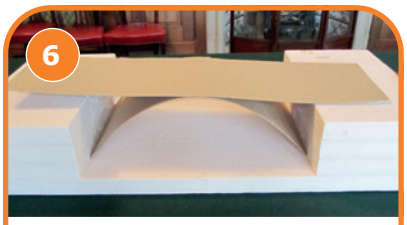
Add a cardboard beam with transverse corrugation (in the direction shown by the ruler).

The cardboard bridge has failed because a "hinge" has formed.

Add a cardboard beam with longitudinal corrugation (in the direction shown by the ruler).

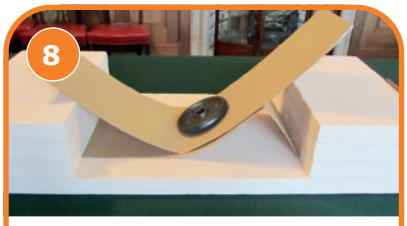


The cardboard bridge has failed but a "hinge" has not formed in this case. This bridge should be able to carry more load than the first one.



Add a cardboard beam with an arched piece of cardboard underneath.

The arch-beam combo holds the load. Should be able to carry more load than either of the other bridges.



But with a heavier load the bridge fails. Hinges have formed in the arch and the beam.

Why did the cardboard bridge fail?

The earliest bridges were felled trees or piles of stones that developed beyond simple stepping stones. In this game, we return to the ancient way of crossing a stream...

In an outdoor space, use some round spot markers (such as those used in PE) in a selection of colours, challenge the teams to get all the way across the river without touching the water in the quickest time possible.

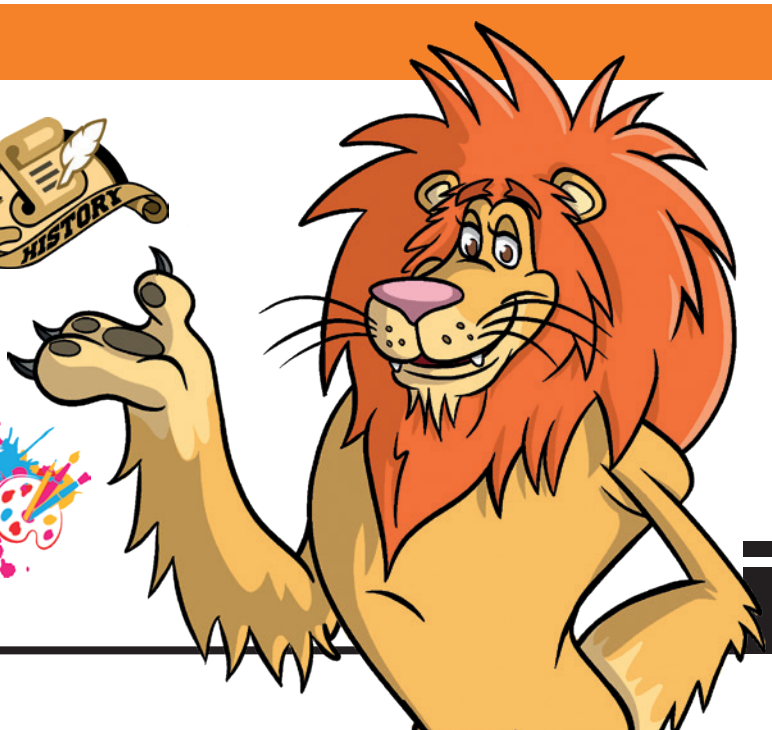
Divide the group into small teams, no more than 5 in a team. Give each team a set of 5 coloured spot markers, with each team getting a different colour if possible. Using either lines marked out already on the ground, or ropes to indicate the sides of the river bank (making the river as big as the area will allow), get the teams to travel from one side of the river to the other, using only the stepping stone spots. They must not step in the river, and they must pick up the markers as they go. The stepping stones will also get washed away if someone isn't touching them; the teams cannot just throw their markers out into the river and wait until they need them – they must carry them with them and have someone collect them as they go.

Challenge them to see how quickly they can get across. Reduce the number of stepping stones and repeat the challenge.

HOT TOPICS!

The earliest stone bridges were likely to be clapper bridges – piles of stones that were laid with larger, flat stones between them. The name is derived from the Anglo-Saxon word, cleaca, which means bridging the stepping stones: it is obvious why they were given this name when viewing images of such bridges!

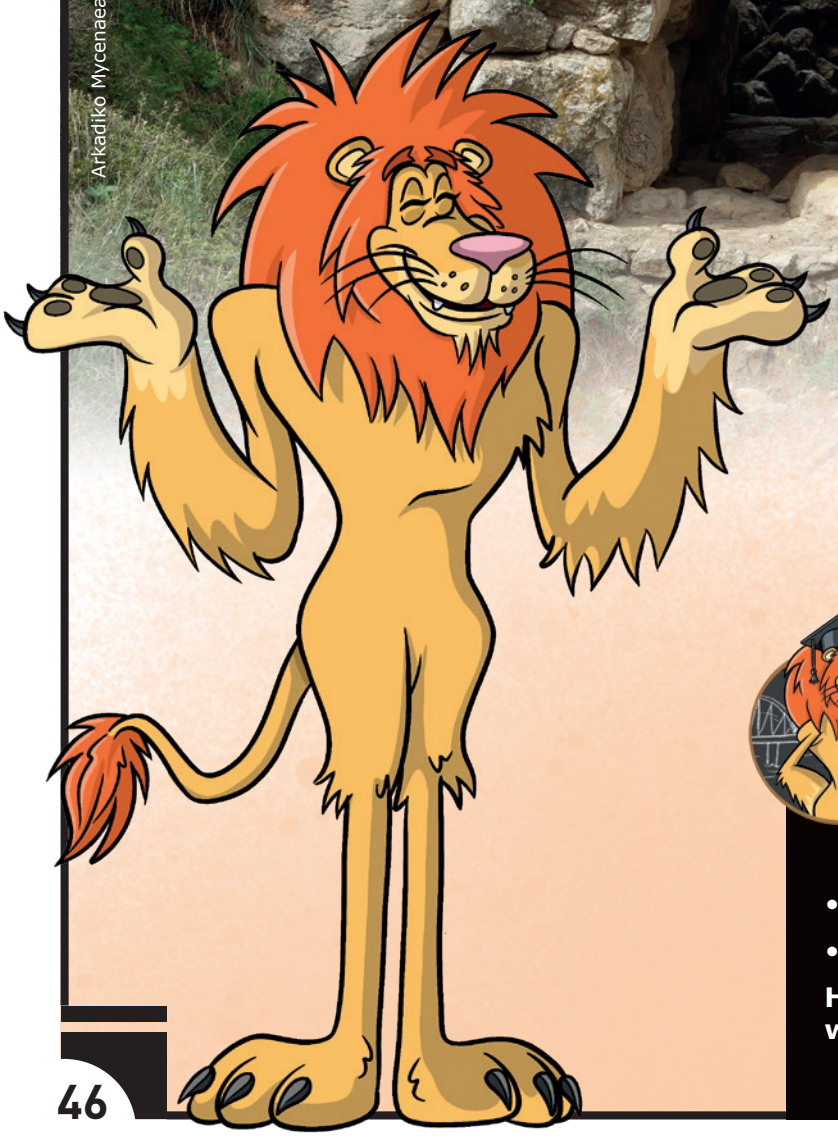
This could link to Anglo-Saxons in history, or perhaps develop sketching and painting skills in art by reviewing different scenes in a similar location, or over time.



OUT & ABOUT

Can you spot a beam bridge in your local area? Take a photo and identify the parapet, abutments, deck and piers, if it has any.

Arkadiko Mycenaean Bridge II (Photo by Flausa123 via Wikimedia)



DID YOU KNOW?

The bridge believed to be the oldest bridge in the world that is still in existence and use today is the Arkadiko Bridge, also known as the Kazarma Bridge. It is in Greece, and is thought to have been constructed around 1300-1190 BCE.

Langdon presents:

- *Beam bridge terminology* handout
- *Beam bridge record sheet* handout

Handouts can be found at www.rochesterbridgetrust.org.uk