Bridge Building

Prepared by Donna King in collaboration with Lyn English, Les Dawes and Peter Hudson
Queensland University of Technology

Funded by an Australian Research Council Linkage Grant, Developmental Engineering Education in the Primary School (LP120200023).
Professor Lyn English, Dr Donna King, Professor Les Dawes and A/Professor Peter Hudson.
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Overview

Students will learn about the structures of bridges and use the (modified) engineering design model to design and test a bridge. Students will learn about changes in materials that can affect the strength of the bridge drawing on previous work about earthquakes. Furthermore, as an introduction to “Change Detectives” (Primary Connections), students will explore chemical changes that impact on bridge stability.

Objectives

Students will be engaged in:

- Learning about aspects of civil engineering and chemical engineering and engineer’s roles.
- Learning about structures of bridges and how to design a bridge that withstands a force.
- Describing changes to the bridge that can affect its stability including natural disasters and chemical changes.
- Developing their problem-solving skills and applying the engineering design processes.

Document Navigator

For ease of use, facing pages in this resource are to be read in conjunction with each other as per the diagram below.
**Class Time:** 3 hours

*The presentation phase at the end is very important to allow students to clarify their thinking and share ideas. Please ensure there is plenty of time to get through all presentations.*

**Materials**

- Combined Teaching Notes / Student Workbook.
- Student Workbook (1 per student).
- QUT supplied DVD containing:
  - All images and diagrams in the Combined Teaching Notes should you wish to show students digitally
  - Modified Engineering Design Model
  - Digital copies of the A4 pictures laminated of different types of bridges
  - ‘Five different types of bridges’ by the Architectural Foundation of Cincinnati ([http://www.architecturecincy.org/programs/design-lab/](http://www.architecturecincy.org/programs/design-lab/))
  - N.B: Pages referring to “cable-stayed” in this document have been removed as they are not applicable to the activity
  - ‘Lesson Plan for Bridge Building’ by Anjali Mulchandani ([beam.ucla.edu/sites/default/files/docs/Bridge_Building.pdf](http://beam.ucla.edu/sites/default/files/docs/Bridge_Building.pdf))
- Book titled “Engibear’s Bridge”.
- plain paper (for construction).
- sticky tape.
- 500g weights for load testing.
- pencil case including scissors, rulers, pencils, rubbers – student supplied.
- A4 pictures laminated of different types of bridges – QUT supplied
## Curriculum Links

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<td><strong>Chemical Sciences</strong></td>
<td><strong>Measurement and Geometry</strong></td>
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<td>• Investigate how people in design and technology occupations address competing considerations, including sustainability in the design of products, services and environments for current and future use (ACTDEK019)</td>
<td>• Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting (ACSSU095)</td>
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<td>• Generate, develop, communicate and document design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (ACTDEP025)</td>
<td>• Sudden geological changes or extreme weather conditions can affect Earth’s surface (ACSSU096)</td>
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<td>• Negotiate criteria for success that include consideration of sustainability to evaluate design ideas, processes and solutions (ACTDEP027)</td>
<td><strong>Science as a Human Endeavour</strong></td>
<td>• Investigate, with and without digital technologies, angles on a straight line, angles at a point and vertically opposite angles. Use results to find unknown angles (ACMMG141)</td>
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**Chemical Sciences**
- Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting (ACSSU095)

**Earth and Space Sciences**
- Sudden geological changes or extreme weather conditions can affect Earth’s surface (ACSSU096)

**Science as a Human Endeavour**
- Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples’ lives (ACSHE100)
- Scientific knowledge is used to inform personal and community decisions (ACSHE220)

**Measurement and Geometry**
- Convert between common metric units of length, mass and capacity (ACMMG136)
PART 1: DIFFERENT TYPES OF BRIDGES - Teacher Notes
(QUT visitors do not come for Part 1)

Introduction

- **Have resources ready** – Five A4 pictures of a beam, truss, suspension, arch and cantilever bridge around the room where students can view them.

- **Read** and discuss the book *Engibear’s Bridge*:
  - Read and discuss the picture book *Engibear’s Bridge* by Andrew King reminding the students that this book was written for younger children. Highlight the important information in the book that will help students to work like engineers today.

- **Explain background information** about bridges:
  Bridges are structures built to get from point A to point B when the land in between is inaccessible. The earliest bridges were simply logs laid across a stream or stones creating a path across a river, and grew to be more advanced by weaving together combinations of sticks, logs, branches, weeds and other fibers to form ropes capable of holding together bridge materials. These simple ideas were the foundations of the beam designs used in modern culture. Bridges today are made of wood, concrete, and/or steel and have many different structures. Some examples include beam, truss, cantilever, arch, suspension, and cable. These are five of the six types of bridges highlighted in Engibear’s book. We have not included cable-stayed in the booklet.

- **Hand out Student Workbook** and ask students to complete their name, group members, group numbers, class and school on the front.

- **Highlight** the **five of the six basic bridge types** explained in the book: Beam, Truss, Suspension, Arch, Cantilever.

**Teacher Information**
A good resource for teacher background information:
http://www.pbs.org/wgbh/buildingbig/bridge/basics.html#beam
Bridge Building
STUDENT WORKBOOK
Year 6

Name: __________________________________________

Other group members: __________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

Group Number: _____________________   Class: _____________________

School: __________________________________________________________________
1. **Beam Bridges**

**Activity 1: Similarities and Differences of Bridges** *(Student workbook page 3)*

**Task**
Ask students to:
- Walk around the room and look at all the different types of bridges that are displayed in A4 pictures with names underneath.
- Think about the similarities and differences of each bridge and record answers in workbook.

Go through their answers and reinforce the similarities and differences. In particular, reinforce the five different types of bridges that were read in the Engibear book.

**Teacher Information**

Here are some ideas of similarities and differences:

**Arch bridges** – These bridges used an arch as a main structural component (arch is always located below the bridge, never above it). They are made with one or more hinges, depending on what kind of load and stress forces they must endure. Examples of arch bridge are “Old Bridge” in Mostar, Bosnia and Herzegovina and The Hell Gate Bridge in New York.

**Beam bridges** – Very basic type of bridges that are supported by several beams of various shapes and sizes. They can be inclined or V shaped. Example of beam bridge is Lake Pontchartrain Causeway in southern Louisiana.

**Truss bridges** – Very popular bridge designs that use diagonal mesh of posts above the bridge. The two most common designs are the king posts (two diagonal posts supported by single vertical post in the center) and queen posts (two diagonal posts, two vertical posts and horizontal post that connect two vertical posts at the top).

**Cantilever bridges** – Similar in appearance to arch bridges, but they support their load not through vertical bracing but through diagonal bracing. They often use truss formation both below and above the bridge. Example of cantilever bridge is Queensboro Bridge in New York City.

**Suspension bridges** – These are bridges that use ropes or cables from the vertical suspender to hold the weight of bridge deck and traffic. An example of a suspension bridge is the Golden Gate Bridge in San Francisco.

1. **Beam Bridges**

**Activity 1: Similarities and Differences of Bridges**

a) **Describe** how the bridges you have seen in the pictures around the room are **similar**.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

b) **Describe** how the bridges are **different**.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

**Additional Notes**… drawings, diagrams, observations, notes, reflections …
Activity 2: Beam Bridges (Student workbook page 5)

Here is a basic picture of a beam bridge.

Students have to answer a question about this image in their Workbooks.

Task
Ask students:
- “What do you think makes a beam bridge strong?”
- “Can you make a beam bridge with your pencil and pencil cases?” Allow students one minute to do this.
- “What would make the pen bend or break – why?”
- Remind students that there are forces acting on the bridge to keep it stable (see diagram below). Ask students to describe the forces and draw them on the diagram in their workbook.

Teacher Information
You may like to highlight some of the background information below to the students:

Beam Bridges are the earliest form of bridges. Cave men and women would have used them to cross rivers and gullies by simply pushing a log into position and walking over the log. The log they walked on is the “beam” and the rocks or land surrounding it supported it and the cave people on top!

These days beam bridges still have a beam – rigid, strong and usually horizontal and the beam is supported by piers – a vertical column/s at either end. A beam bridge’s strength depends on the strength of the beam and the piers. If the length of the beam – the span – is too long to hold its own weight it would bow in the middle.

Here is a simple diagram of the forces that act on a beam bridge. Students will be asked to label the compression and tension forces on a blank diagram in their Workbooks.

Diagram from:  

Tension: What happens to a rope during a game of tug-of-war? Correct, it undergoes tension from the two sweaty opposing teams pulling on it. This force also acts on bridge structures, resulting in tensile stress.

Compression: What happens when you push down on a spring and collapse it? That’s right, you compress it, and by squishing it, you shorten its length. Compressional stress, therefore, is the opposite of tensile stress.

Source:  
http://science.howstuffworks.com/engineering/civil/bridge2.htm
Activity 2: Beam Bridges

Here is a picture of a simple beam bridge

Make a beam bridge with your pencil, rubbers and rulers.

a) What supports the beam bridge across the bridge?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

b) What would make the beam of the bridge break?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

c) You have learnt about forces in Year 4. There are forces acting on the bridge to keep it stable. Label the compression forces and tension forces in the diagram below:

Label the compression forces and tension forces in the diagram below:
Activity 3: Trusses that support a beam bridge (Student workbook page 7)

Here is a Truss Bridge:

Students have to answer a question about this image in their Workbooks.

**Task**

Ask students to:
- Describe how a Truss bridge is different to a Beam Bridge. Ask students to think about the shapes in the structure. Record answers in the workbook.
- Complete Activity Three on the Truss Bridge Structure in the workbook.

### Teacher Information

**What is the difference between Truss and Beam Bridges?**

Additional piers can be added or the beam can be strengthened by supporting the beam with trusses. Trusses are triangular units which are used to hold the bridge together like this picture:

Beam bridges are usually made of concrete and steel with a maximum span between piers of 80 metres. Trusses have a high strength to weight ratio, can span longer distances than beam bridges and are used in many structures including bridges, roofs, and rockets. Truss bridges can span up to 180 metres.
Activity 3: Truss Bridge

Here is a picture of a Truss Bridge, which has a beam bridge foundation but an extra part on the top.

a) What do you notice has been added to the beam bridge to support the bridge?
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

b) What shape/s are the structures that have been added?
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

Additional Notes... drawings, diagrams, observations, notes, reflections ...
Activity 4: A Cantilever Bridge (another type of Beam Bridge) (Student workbook page 9)

Below is a photo of the Bolte Bridge in Melbourne – a cantilever bridge.

Students have to answer a question about this image in their Workbooks.

**Task**
Ask students:
- “Has anyone seen bridges like these?”
- “What do they have in common with the beam bridge and truss bridge?”
- “What is different about them?” Record answers in workbook.
- Complete Activity Four in the workbook.

**Teacher Information**

Cantilever bridges – Similar in appearance to arch bridges, but they support their load not through vertical bracing but through diagonal bracing. They often use truss formation both below and above the bridge.

This diagram shows a cantilever bridge supporting a load:

Source: http://www.design-technology.org/cantileverbridges.htm
**Activity 4: Cantilever Bridge**

Here is a picture of a Cantilever Bridge:

![Cantilever Bridge](image)

a) What do you notice is **different** about this bridge when compared to a beam bridge or truss bridge?

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

b) What do you notice is **similar** about all three types of bridges (truss, beam, and cantilever)?

___________________________________________________________________________

___________________________________________________________________________

**Additional Notes**… drawings, diagrams, observations, notes, reflections …
2. **Arch Bridges** *(Student workbook page 11)*

**Task**
- Show students A4 picture of arch bridge (‘basic picture of an arch bridge’ seen below).

**Ask students:**
- “What is different about this bridge compared to the beam bridges we looked at before?”
- “What is similar?”
- “Has anyone seen a bridge like this before?”
- To complete “Arch Bridges” activity in the workbook.

**Teacher Information**
Arch Bridges have been built since the Roman times and were originally made of stone, allowing people to travel over the top of the arch. Later arch bridges were made of metal. These days they are mainly made of concrete as it can be readily moulded into a variety of shapes. Arch bridges often incorporate a beam or roadway upon which the traffic travels.

Modern arch bridges can span 450 metres and due to the nature of their design they leave the water below free from obstruction by supporting piers. An arch bridge gains its strength from the shape of the arch and the strength and stability of the abutments (the structures at the bottom of the arch that stop the ends of the arch from spreading out) and the ground in which they are positioned.

Here is a basic picture of an arch bridge.

![Basic picture of an arch bridge](image)

Students have to answer a question about this image in their Workbooks.

Here is a simple diagram of the forces acting on an arch bridge. The red arrow shows the location of the force and the direction of the force. Students have to answer a question about this image in their Workbooks.

![Diagram of forces on an arch bridge](image)
Extra Teacher Information

The diagram below provides additional information about the forces on an Arch bridge and terminology:

![Arch diagram](https://engineeringrome.wikispaces.com/A+look+into+the+longevity+of+Roman+Engineering)

Above picture for teachers only.

This is a photo of the Sydney Harbour Bridge – an arch bridge incorporating a beam.

Students have to answer a question about this image in their Workbooks.
2. Arch Bridges

Here is a picture of an arch bridge:

![Image of an arch bridge]

a) **Why** is it called an “Arch Bridge?”

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

b) **Draw** the forces that are acting on an arch bridge in this diagram:

![Diagram of forces on an arch bridge]

c) The picture below is of the Sydney harbour bridge.

![Image of Sydney Harbour Bridge]

What **types of bridge structures** can you see in this picture?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
3. Suspension Bridges (Student workbook page 13)

**Task**
- Show students A4 picture of suspension bridge.
- Ask students:
  - “Why do you think it is called a suspension bridge?”
  - “What is suspending the bridge?”
  - “How could you make a model of a suspension bridge?”
  - “What resources would you need?”
  - To complete the workbook questions on suspension bridges.

**Teacher Information**
Suspension bridges are very strong and can span distances of up to 2000 metres making them ideal bridges to span harbours. The main structural elements of a suspension bridge are the two towers – usually made of concrete or steel, steel wire cables, the roadbed, and the steel cables holding the roadbed in place. The cables loop over the top of the two towers and are anchored at each end.

Here is a basic picture of a suspension bridge.

![Suspension Bridge Diagram](image)

Students have to answer a question about this image in their Workbooks.

Here are the forces on a suspension bridge:

![Forces in Suspension Bridge Diagram](image)

Students have to answer a question about this image in their Workbooks.

**Teacher Information**
Here is some more detailed information about the forces:

![Suspension Bridge Forces Diagram](image)

©2000 How Stuff Works
3. Suspension Bridges

Here is a picture of a suspension bridge:

![Suspension Bridge](image)

a) **Why** do you think it is called a Suspension bridge?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

b) There are **many forces** operating on a suspension bridge to enable it to be stable and strong. **Draw** in some of these forces on the diagram below:
PART 2: ENGINEERING DESIGN PROCESS
*(QUT visitors will be present for Part 2)*

Summarise with students the five different types of bridges and how engineers use opposing compressional and tensional forces to create stable and safe bridges. Explain to students that engineers determine the best type of bridge to suit an environment based on the bridge loads, soil conditions and cost. Engineers must consider many things -- like the distance to be spanned and the types of materials available -- before determining the size, shape, and overall look of a bridge. The Engineering Design Process is a method used by engineers to understand and overcome design problems.

Remind students of the Engineering Design Process that they have done in previous engineering units which will be something they have to use in their challenge today. Ask students to explain the process to check for understanding. A copy of the process can be found on the teacher DVD. This can be referred to during the discussion and left displayed on the whiteboard for students to access during the challenge.

*NOTE: Engineering model has changed – if they wish, students can now experiment with the materials before designing.*

**Engineering Design Model**

![Engineering Design Model Diagram](image)

Model adapted from pbs.org model
PART 3: BUILDING A BRIDGE  

**Introduction**

- Explain to students that today they are acting like engineers. They will make models of bridges and conduct an experiment to test how well their structure stands up to load capacity testing i.e. the maximum weight the bridge can support. Explain to them that this is similar to what some civil (structural) engineers do as theirs jobs.
- Ask students to read through the scenario carefully.

**PROBLEM**

**Scenario:** You have been asked by the DEEP Engineering Company (DEEPEC) to submit a design and model to the Brisbane City Council for another footbridge across the Brisbane River. The bridge will need to be wide enough to span the river and high enough for boats to pass under it. Council have asked for 1 in 100 scale models of the bridge (i.e., 1 cm in your model represents 1m in real life) and have provided the specifications for the required models in Table 1.

<table>
<thead>
<tr>
<th>Minimum Span (pier to pier)</th>
<th>Minimum Clearance (at bridge centre)</th>
<th>Minimum Deck Width</th>
<th>Minimum Load Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 cm (A4 sheet width)</td>
<td>15 cm (A4 sheet length / 2)</td>
<td>15 cm (A4 sheet length /2)</td>
<td>500 g (~ 1 Engibear book)</td>
</tr>
</tbody>
</table>

A diagram of A4 paper dimensions is below for reference.

Strength and safety are the most important aspects of bridge design. The bridge should be capable of supporting the specified minimum load capacity. Environmental impacts and construction costs are also of concern; bridge designs that provide the required span and load capacity with minimal material use in construction will be looked upon favourably.

Remember to follow the **Engineering Design Model**.

Council are happy to look at a range of bridge designs and will consider bridges of all types; including beam bridges, arch bridges, suspension bridges.
PART 3: BUILDING A BRIDGE

1. PROBLEM

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Table 1 Brisbane City Council Footbridge Model Specifications

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Remember to follow the Engineering Design Model.

Council are happy to look at a range of bridge designs and will consider bridges of all types; including beam bridges, arch bridges, suspension bridges.
Council have advertised for bridge design submissions which must include:

➤ **MATERIALS AND EQUIPMENT**
- You will be given 30 sheets of paper plus an additional 10 sheets of paper for preliminary testing.
- 1 small roll of sticky tape per group.
- 500g weights

➤ **CHALLENGE**
Using the materials listed you will design a bridge with the specifications above. You will include:

1. A design drawing of the bridge including your group name.
2. A 1 in 100 scale model of the bridge (1 cm represents 1m).
3. A list of the amount of material (paper and sticky tape) actually used in construction of the model bridge. These should be listed on the drawing. An approximate measurement (in centimetres) of the amount of sticky tape used is required.
4. Certified load testing performance of the model. Tests will be witnessed by supervising engineers and teachers and results recorded on the drawings.
5. You will work in groups of 3.
6. You will apply the **modified engineering design model** as you work.
7. You will be given 30 sheets of paper and 1 small roll of sticky tape per group.
8. Additional paper (10 sheets) will provided to do some preliminary testing of designs prior to starting work on their full scale bridge.

The group whose final design withstands certified load testing and provides the required span is the winner of the Challenge. If more than one group achieves this, the bridge with the least materials used in construction will win.

**EXAMPLE BRIDGES ARE PROVIDED OVER PAGE FOR TEACHER REFERENCE ONLY.**
Council have advertised for bridge design submissions which must include:

2. MATERIALS AND EQUIPMENT

- You will be given 30 sheets of paper plus an additional 10 sheets of paper for preliminary testing.
- 1 small roll of sticky tape per group.

3. CHALLENGE

Using the materials listed you will design a bridge with the specifications above. You will include:

1. A design drawing of the bridge including your group name.
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4. Certified load testing performance of the model. Tests will be witnessed by supervising engineers and teachers and results recorded on the drawings.
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The group whose final design withstands certified load testing and provides the required span is the winner of the Challenge. If more than one group achieves this, the bridge with the least materials used in construction will win.

Kurilpa Bridge in Brisbane's CBD
Teacher Information
(FOR TEACHERS ONLY)

Here is an example by Andrew King:

As a guide, the example bridge shown in Figure 1 meets the minimum specifications in Table 1 and was constructed from 14 sheets of A4 paper and much less than 1 small roll of sticky tape. It weighs 75 g and could support a load of about 1.5 kg (3 Engibear books) as shown in Figure 2-3. 500g weights will be provided for your testing.

STAGE 1

Figure 1 Example paper bridge

Example continued overleaf.
STAGE 2

Figure 2 Holding 3 books (~ 1.5 kg)

STAGE 3

Figure 3 Bridge failure at 4 books (~ 2 kg)
4. BRAINSTORM (Student workbook page 19)

Explain that squares and triangles are like building blocks that may be arranged and fixed together to make bridges.

Have students discuss and record answers to the following questions in their Student Workbook.

- What type of bridge do you want to build?
- What shapes will you use for your bridge?
- How tall will the bridge be?
- How wide will the bridge be?
- How will you make it strong?
- Draw and label some draft designs in the ‘Thinking Space’ provided on page 11 of Student Workbook.

5. EXPERIMENT (Student workbook page 19)

Remind students of the dimensions of an A4 sheet of paper. There is a diagram of the dimensions on page 8 in their Workbook if they require.

Distribute kits of 40 sheets of A4 paper (30 for final construction and 10 for experimentation) and 1 small role of sticky tape to each group. This is just a starter pack. Students may choose to use more or less of each of the materials however, as previously stated, bridges with minimal material use in construction would be looked upon favourably. Students are allowed to modify the paper as desired i.e. cut, tear etc.

Ask students to work with the materials and experiment with different construction and design methods. Students do not have to build their final structure at this stage but should be encouraged to discuss options/cost and start trialing possible designs. The discussion here should be rich as students negotiate with each other. Finally, they should agree on the design they will build from the options they have discussed.
4. BRAINSTORM

Discuss the questions below with your group. Record your answers in the box.

- **What type** of bridge do you want to build? Why?
  
- **What shapes** will you use for your bridge?
  
- **How tall** will the bridge be? ________________
  
- **How wide** will the bridge be? ________________
  
- **How** will you make it **strong**?

- Draw and label some draft designs in the ‘Thinking Space’ on page 18.

5. EXPERIMENT

- Your group will be given 30 sheets of paper and 1 small role of sticky **tape**. Additional paper (10 sheets) will be provided to do some preliminary testing of designs prior to starting work on a full scale bridge.

- If you wish, you can work with the materials and experiment with different **construction methods**. You are allowed to modify your paper as desired i.e. cut, tear etc.

- Discuss possible **designs** with your group, taking into account the **quantity** of materials you use.
6. DESIGN *(Student workbook page 21)*

After students have experimented and come up with a suitable design, ask them to draw the design in their workbooks. Emphasise the need for students to draw and label the shapes with appropriate geometrical terms and to put measurements on the designs. They also need to be mindful of the amount of materials they use.
6. DESIGN

- **Draw** and **label** your first design.
- Make sure you **label the shapes** you used with the correct names.
- **Remember** to put **measurements** on the design.
- **Note** the **amount of materials** you use.
7. **BUILD** *(Student workbook page 23)*

Allow groups time to build their bridges. They may have started this during the ‘experiment stage’ but encourage students to refine it here and make sure that it is exactly how they would like it before testing.

Groups also need to calculate the total amount of materials used in their bridge using the table below.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Number used</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A4 paper</strong></td>
<td></td>
</tr>
<tr>
<td>(Number of sheets used)</td>
<td></td>
</tr>
<tr>
<td><strong>Sticky tape</strong></td>
<td>cm</td>
</tr>
<tr>
<td>(Approximate number of cm used)</td>
<td></td>
</tr>
</tbody>
</table>
7. **BUILD**

**Build** your structure using the materials supplied.

**Calculate** the amount of materials used in your bridge. **Record** the quantity of materials in the table below.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Number used</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4 paper (Number of sheets used)</td>
<td></td>
</tr>
<tr>
<td>Sticky tape (Approximate number of cm used)</td>
<td>cm</td>
</tr>
</tbody>
</table>
8. TEST *(Student workbook page 25)*

Have groups test their bridges under capacity loading with adult supervision. Students record what happens to their bridges during the simulated loading by answering the following questions in their Student Workbooks.

- Place your bridge flat on a table. Place one 500g weight on top of the bridge. This will test the minimum load capacity. Observe, describe and record what happens when the first weight is placed on the bridge.
- Continue to place extra 500g weights on top of the bridge, one at a time, to see how many it will hold. The bridge will reach its maximum load capacity when the structure starts to buckle under the weight. Observe, describe and record what happens when the final weight is placed on the bridge.
- How many weights did the bridge hold?
- What total weight did the bridge hold?
- What did you learn about your bridge from the test (including any maths and science that you used)?
8. TEST

Write answers to the following questions.

a) Place your bridge flat on a table. Place one 500g weight on top of the bridge. This will test the minimum load capacity. Observe, describe and record what happens when the first weight is placed on the bridge.

__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

b) Continue to place extra 500g weights on top of the bridge, one at a time, to see how many it will hold. The bridge will reach its maximum load capacity when the structure starts to buckle under the weight. Observe, describe and record what happens when the final weight is placed on the bridge.

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__________________________________________________________________________________
__________________________________________________________________________________


c) How many weights did the bridge hold?

__________________________________________________________________________________


d) What total weight did the bridge hold?

__________________________________________________________________________________


e) What did you learn about your bridge from the test (including any maths and science that you used)?

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__________________________________________________________________________________
__________________________________________________________________________________
9. EXPERIMENT AND REDESIGN *(Student workbook page 27)*

Students discuss and write answers to the following questions.

- What can you change to improve your design?
- How will these changes make your bridge better?
9. EXPERIMENT AND REDESIGN

Write answers to the following questions.

a. **What** can you **change** to improve your design?

__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

b. **How** will these changes make your bridge **better**?

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__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
(Student workbook page 29)

Students can experiment with alternative construction methods. They may choose to make changes to their existing bridge or build an entirely new bridge.

Students then draw and label their improved design.
Draw and label your improved design below.
10. REBUILD *(Student workbook page 31)*

Students build a second bridge that improves on the first design’s weaknesses. They may have started this during the ‘experiment and redesign stage’ but encourage students to refine it here and make sure that it is exactly how they would like it before testing.

Groups also need to recalculate the total amount of materials used in their bridge using the table below.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Number used</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4 paper</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Number of sheets used)</td>
</tr>
<tr>
<td>Sticky tape</td>
<td>cm</td>
</tr>
<tr>
<td></td>
<td>(Approximate number of cm used)</td>
</tr>
</tbody>
</table>
10. **REBUILD**

**Rebuild** your new and improved bridge.

**Calculate** the amount of materials used in your new bridge. **Record** the quantity of materials in the table below.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Number used</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4 paper</td>
<td></td>
</tr>
<tr>
<td>(Number of sheets used)</td>
<td></td>
</tr>
<tr>
<td>Sticky tape</td>
<td>cm</td>
</tr>
<tr>
<td>(Approximate number of cm used)</td>
<td></td>
</tr>
</tbody>
</table>
11. RETEST (Student workbook page 33)

Have groups test their redesigned bridges under capacity loading with adult supervision. Students record what happens to their bridges during the simulated loading by answering the following questions in their Student Workbooks.

- Place your bridge flat on a table. Place one 500g weight on top of the bridge. This will test the minimum load capacity. Observe, describe and record what happens when the first weight is placed on the bridge.
- Continue to place extra 500g weights on top of the bridge, one at a time, to see how many it will hold. The bridge will reach its maximum load capacity when the structure starts to buckle under the weight. Observe, describe and record what happens when the final weight is placed on the bridge.
- How many weights did the bridge hold?
- What total weight did the bridge hold?
- What did you learn about your bridge from the test (including any maths and science that you used)?
11. RETEST

Write answers to the following questions.

a) Place your bridge flat on a table. **Place one 500g weight** on top of the bridge. This will test the minimum load capacity. **Observe, describe and record** what happens when the first weight is placed on the bridge.

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

b) **Continue to place extra 500g weights on top of the bridge, one at a time,** to see how many it will hold. The bridge will reach its maximum load capacity when the structure starts to buckle under the weight. **Observe, describe and record** what happens when the final weight is placed on the bridge.

__________________________________________________________________________________

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c) **How many** weights did the bridge hold?

__________________________________________________________________________________

d) **What total weight** did the bridge hold?

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e) **What** did you **learn** about your bridge from the test (including any maths and science that you used)?

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12. PRESENTATION (Student workbook page 35)

The presentation phase is very important to allow students to clarify their thinking and share ideas. Please ensure there is plenty of time to get through all presentations.

Each group of students is to present their best design to the class. The class acts as representatives of DEEP Engineering Company (DEEPEC) asking questions and offering feedback/constructive comments.

Each group should include the following in their presentation:

- A description of their bridge and what bridge design you have used (e.g. arch, beam, shapes used, dimensions).
- How the bridge withstood capacity testing (e.g. how many weights and total weight the bridge held).
- The amount of materials used.
- Why this was their best design.

The teacher has the final say on which bridge/s win/s the challenge.
12. PRESENTATION

Present your best bridge design to the class.

- Use the ‘Thinking Space’ on page 34 to plan your presentation.
- Include the following points in your presentation.

- **A description** of their bridge (e.g. shapes used, dimensions) and what bridge design you have used (e.g. arch, beam).
- **How** the bridge withstood capacity testing (e.g. how many weights and total weight the bridge held).
- The **amount** of materials used.
- **Why** this was your best design.
13. REFLECTING *(Student workbook page 37)*

This section can be completed the following day if there is insufficient time.

Allow students time to discuss and write answers to the following questions:

- Which was your best design and why?
- What would you do to further improve your design?
- In what ways were you working like a civil engineer today?
- Write down everything about how you were using mathematics and science ideas today for the design of your bridge. You can use diagrams in your explanation.
13. REFLECTING

Write answers to the following questions.

a. Which was your best design and why?

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b. What would you do to further improve your design?

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C. In what ways were you working like a civil engineer today?

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D. Write down everything about how you were using mathematics and science ideas today for the design of your bridge. You can use diagrams in your explanation.
Feedback *(Student workbook page 39)*

This section can also be completed the following day if there is insufficient time.

Finally, have students complete the *Bridge Building Challenge Feedback* by colouring in the face to show how they felt about the different parts of the challenge.
**BRIDGE BUILDING CHALLENGE FEEDBACK**

Please **colour in the face** to show how you felt about the different parts of the *Bridge Building Challenge.*

<table>
<thead>
<tr>
<th>Did you like:</th>
<th>Did not like it</th>
<th>Not sure</th>
<th>Liked it</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ... the activities about bridges?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ... having a real problem to solve?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. ... designing a model of a bridge?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. ... making a model of a bridge?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. ... testing your model of a bridge?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. ... recording the results of the test of your model of a bridge?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. ... doing a presentation about your model of a bridge?</td>
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<td></td>
</tr>
<tr>
<td>8. ... thinking about how to make your model of a bridge better?</td>
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</tbody>
</table>

**Next time I would like to:**

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PART 4: HOW THE WEATHER CAN AFFECT THE STABILITY OF THE BRIDGE
(QUT visitors will not be present for Part 4)

Activity 1: External changes to a bridge (Student workbook page 41)

Task
With the students:
- Discuss: External changes caused by weather may affect the stability of a bridge over time.
- Brainstorm some possible changes that could affect a bridge. (Answers may include earthquakes, floods, natural disasters, erosion by wind or water poor maintenance, fire, train crash, boat impact, construction accidents, design defect and odd occurrences that can’t be explained etc…)

Ask students:
- To answer questions about this in the workbook

Teacher Information

Some good information can be found at:

http://science.howstuffworks.com/engineering/structural/10-reasons-why-bridges-collapse.htm#page=10
PART 4: HOW THE WEATHER CAN AFFECT THE STABILITY OF THE BRIDGE

Activity 1: External changes to a bridge

a) **How** do external changes caused by weather affect the **stability** of a bridge over time?

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b) What are some **possible changes** that could affect a bridge? For example natural disasters, problem in the design, boat accident.

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**Additional Notes**… drawings, diagrams, observations, notes, reflections …
Activity 2: Chemical Changes to a Bridge (Student workbook page 43)

Task
With the students:
- Discuss: Other changes to bridges may be due to environmental impacts over time. One example is a chemical reaction that corrodes the steel in the bridge known as rusting.

Ask the students:
- “What is rusting?” “What does it look like?”
- “What can be done to prevent bridges rusting away?” (Answers: regular safety checks, coating the iron with a protective layer that prevents rusting)
- To answer questions about this in the workbook

Teacher Information
A chemical change is where a substance is transformed into a new substance (or substances) at the molecular level. In this case, Iron (Fe) reacts with water and oxygen and is changed into Iron Hydroxide (often seen as reddish brown flakes that loosely adhere to the iron).

Some bridges have rusted away at the foundations causing the bridge to collapse.

Here is one example:

http://35wbridge.pbworks.com/w/page/900718/Mianus%20River%20Bridge%20Collapse

Activity 2 continued overleaf
Activity 2: Chemical Changes to a Bridge

a) **What** is rusting? What does it **look** like?

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b) What can be done to **prevent** bridges rusting away?

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**Additional Notes**… drawings, diagrams, observations, notes, reflections …
Activity 2 (Contd)

Task
With the students:

- Discuss another type of corrosion that occurs on bridges is: Concrete corrosion
- Discuss: Water mixed with concrete bonds with the dry components, forming what is known as a hydrate. Making concrete is a chemical change.
- Explain that the steel to make bridges is often covered in thick layers of concrete but it can wear away exposing the steel that can then corrode.
- Show pictures of concrete corroding on the QUT supplied DVD

Teacher Information

Bridge foundations are often made of multiple piles, which look like circular columns, and can be made from wood, steel or reinforced concrete. These can corrode over time. There are steel reinforcements in the concrete, which can corrode due to weathering. The concrete is layered over the steel to stop it from corroding but this can still be weathered away causing corrosion to both the concrete and the steel. Corrosion is a chemical change.

Some pictures of concrete corroding have been provided on the DVD supplied by QUT.

Here are some useful websites:

http://simscience.org/cracks/advanced/concrete2.html
http://corrosion-doctors.org/Bridges/Concrete.htm
**Activity 3: Physical Changes to a Bridge** *(Student workbook page 45)*

**Task**

**With the students:**
- Explain physical changes to students (information below and in “Change Detectives”).

**Ask the students:**
- “Can you think of any physical changes that may affect the stability of the bridge?”
- “Are there any physical changes that may impact on a pedestrian’s safety when walking on the bridge?”
- Students to answer questions about this in the workbook

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**Teacher Information**

A chemical change is different to a physical change. With a chemical change the substance changes its composition to form something completely new. The compound that is formed after rusting is different to the original metal. With a physical change the substance may look different but it is still made up of the same molecules (e.g., ice melting to water).

Discuss: Soils that bridges are placed on and how this can be affected by physical changes such as flooding, natural disasters etc…

Engineers must consider many other things when designing the foundations for a bridge or structure. They must think about the weight or force bearing down on the soil from the bottom of foundation, called the bearing pressure, to understand if the soil can hold up the structure. They must also think about the settlement of the structure over time.

**Source:**

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*Activity 3 continued overleaf*
**Activity 3: Physical Changes to a Bridge**

a) Can you think of any physical changes that may affect the stability of the bridge?

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b) Are there any physical changes that may impact on a pedestrian’s safety when walking on the bridge?

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Additional Notes… drawings, diagrams, observations, notes, reflections …
Activity 3 (Contd) (Student workbook page 47)

Task

With the students:

- Discuss: “Have you ever seen something that has sunk into the ground over time?” Well, that can happen to bridges as well, if the foundations are not designed properly.
  - “What do you think could happen if there was a lot of water washing over the soil on which the foundations of the bridge had been laid?” “Is this a physical or chemical change?” (Answer: Physical change since the soil has not changed to anything else it has just been moved from one place to another)

- Answer questions about this in the workbook
Activity 3: Physical Changes to a Bridge

c) Have you ever seen something that has sunk into the ground over time? What was it and where did you see it?

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d) What do you think could happen if there was a lot of water washing over the soil on which the foundations of the bridge had been laid?

___________________________________________________________________________
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___________________________________________________________________________


e) Is this a physical or chemical change?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

Additional Notes… drawings, diagrams, observations, notes, reflections …
Conclusion *(Student workbook page 49)*

This is the link to the next unit.

**With students:**

- **Explain:** We will now look at physical and chemical changes in detail through the unit “Change Detectives”
UP NEXT

We will look at physical and chemical changes in detail through the unit “Change Detectives”