SCIENCE & TECHNOLOGY IN SOCIETY

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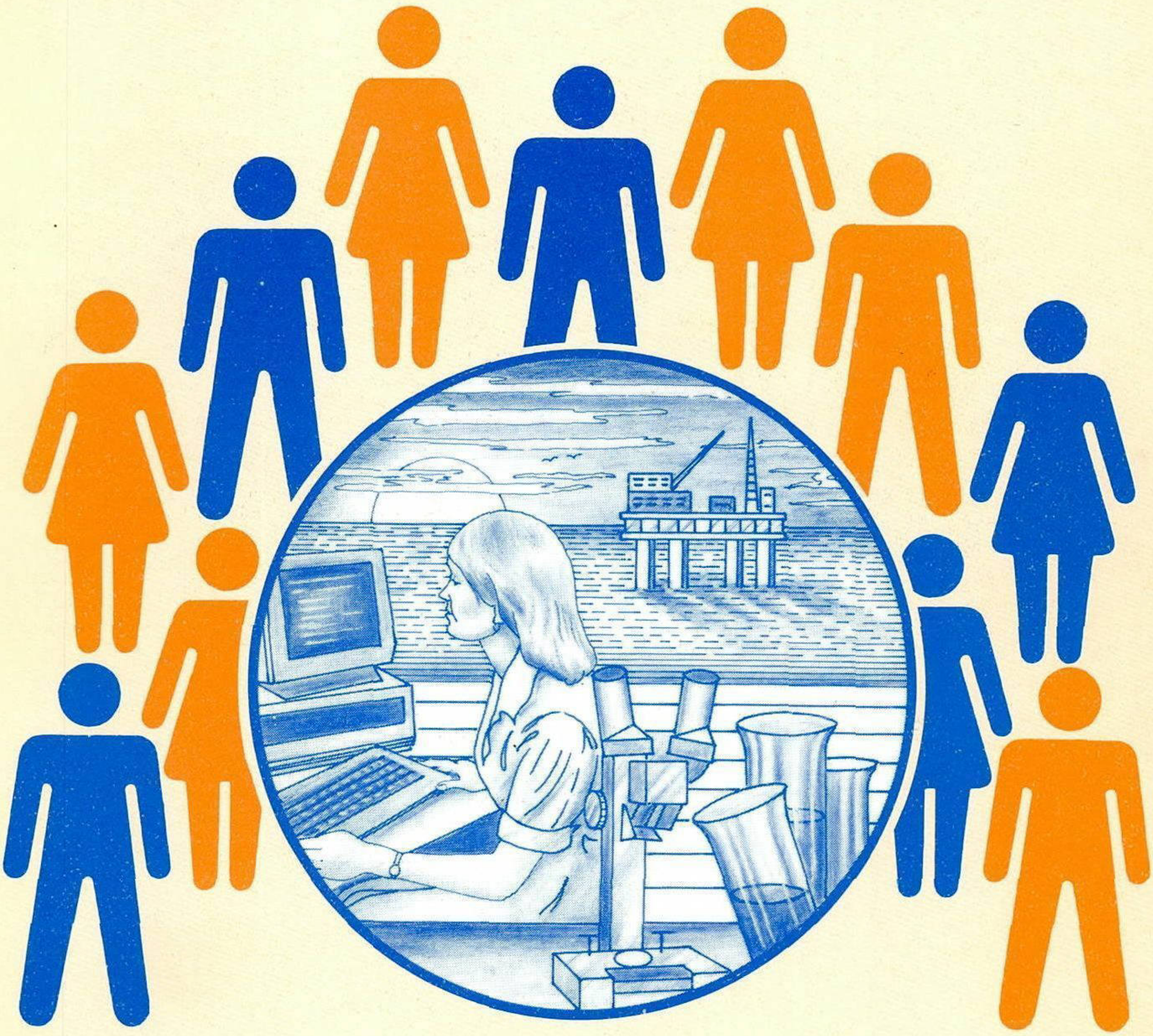

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SATIS

ABOUT SATIS

Science and Technology in Society units are designed to be used in conjunction with conventional science courses, particularly those leading to GCSE examinations. Each unit has links to major science topics as well as exploring important social and technological applications and issues.

The units are self-contained and generally require about 2 periods (around 75 minutes) of classroom time. Each unit comprises Teachers' Notes (blue sheets) and Students' materials (white sheets). Full guidance on use is given in the Teachers' Notes accompanying each unit, which also include background information and suggest further resources.

Each SATIS book contains ten units. The units are numbered in a system giving the number of the book followed by the number of the unit within that book. Thus the first unit in the first SATIS book is numbered 101.

In addition to the SATIS books, a general Teacher's Guide to the project is available, giving guidance on some of the teaching techniques involved as well as ideas for further activities.

Many people from schools, universities, industry and the professions have contributed to the writing, development and trials of the SATIS project. A full list of contributors appears in the Teachers' Guide.

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SATIS 5

List of units in this book.

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List of units in the SATIS series

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102 Food from Fungus
103 Controlling Rust
104 What's in our Food? — a look at food labels
105 The Bigger the Better
106 The Design Game
107 Ashton Island — a problem in renewable energy
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Bridges

Contents: A survey of bridges leading to consideration of bridge design, the choice of materials for bridge construction, and optional practical work.

Time: 2 to 8 periods, depending on number of parts done. Homework time could be used.

Intended use: GCSE Physics, Integrated Science or Technology. Links with work on forces, structures and materials.

Aims:

- To complement work on forces, structures and materials
- To develop awareness of the importance of design and materials selection in bridge construction
- To encourage students to look for applications of science and engineering in the world around them
- To provide opportunities to practise a variety of skills, including observation, interpretation, comprehension, problem-solving and design.

Requirements: Students' worksheets No. 501.

- *For Part 1* see notes below
- *For Part 4* if the design task is undertaken, it will be necessary to provide the class with a range of materials. See page 7 for details.

This unit is in four parts. It is not intended that all four parts should necessarily be attempted.

Part 1 Looking at bridges The survey of a range of bridges is a useful initial stimulus for the unit. It can be tackled in a number of ways.

(a) Using slides showing familiar bridges. Up to about twenty-five slides will be needed. It is best if most of these slides are local, and the production of the slide set can be an interesting project for a keen photographer or for members of a photography club. The slides should cover a range of bridge types and show a variety of materials (wood, stone, brick, cast iron, steel, concrete). Just a plank of wood across a ditch can be regarded as a bridge.

(b) Sending students out to look at local bridges. Obviously this procedure is more time-consuming, though homework time can be used and students can be given an extended period to carry out the task. Students could be encouraged to look for bridges on their way to and from school. Alternatively, the teacher might produce a local map showing the location of bridges which students can visit.

The final column of the table headed 'Notes' can be used to give the name of the bridge, state its location, give the date of construction, etc.

Part 2 Why are bridges shaped the way they are? This part looks at some simple principles of bridge design.

Part 3 What are bridges made from? This part takes a brief look at the materials used for bridge construction.

Part 4 Design your own bridge This optional practical work is intended as an open-ended, problem-solving design-and-build task. The paper bridge can be built quite quickly, but more complex bridges made from other materials may need an extended period.

Further questions and activities

If the teacher wishes, and if time permits, further discussion of bridges might be stimulated by the following questions:

1 Which local bridges are made of local building materials? Which local bridges are made from materials brought from elsewhere?

2 What were bridges usually made of three hundred years ago? What materials were used to make the bridges built when the canals were being constructed (1760–1830)? What did the engineers who built the railways use to make their bridges (1830–1890)? What do civil engineers now use to make motorway bridges?

3 Why are suspension bridges made of steel and not concrete? Why are many motorway bridges made of concrete and not steel? Why are large concrete bridges reinforced with steel? Compare the advantages and disadvantages of steel and concrete as bridge building materials.

4 'Suspension bridges are really arch bridges upside down'. Explain.

5 Make a study of bridges which move. Why are moving bridges necessary and why do engineers use different types of moving bridges in different situations? Possible examples:

  Tower Bridge, which is a bascule bridge
  The lift and the transporter bridges over the Tees at Middlesbrough
  Pontoon bridges used by armies
  The Barton swing aqueduct
  Canal swing bridges on the Leeds-Liverpool canal
  Canal lift bridges on the Oxford and Llangollen canals
  Drawbridges in castles.

6 More advanced work could involve calculations using data for real bridges, to get some idea of the magnitude of the forces involved. Data is available from the organization which manages the bridge.

Further resources

The Federation of Civil Engineering Contractors publish a wallchart and copyright-free set of teachers' notes called *Spanning the Centuries*. They include a plan for ten lessons on bridges as well as ideas for projects, visits and discussions. From the Federation of Civil Engineering Contractors, Cowdray House, 6 Portugal Street, London WC2A 2HH.

The Physics Curriculum Development Project (PLON) from the Netherlands includes an excellent short module on bridges, from which parts of this unit were developed. The module has been translated into English and is available from: PLON, Physics Education Department, State University of Utrecht, PO Box 80-008, 3508 TA Utrecht, The Netherlands.

Acknowledgements Figures 2, 4, 5, 6, 7, 9 and 10 are reproduced by permission of State University of Utrecht, PLON.

BRIDGES

Bridges are everywhere and of all sorts of shapes and sizes. Figure 1 shows some of the main types. In this unit you will be looking at examples of bridges and finding out why bridges are built the way they are.

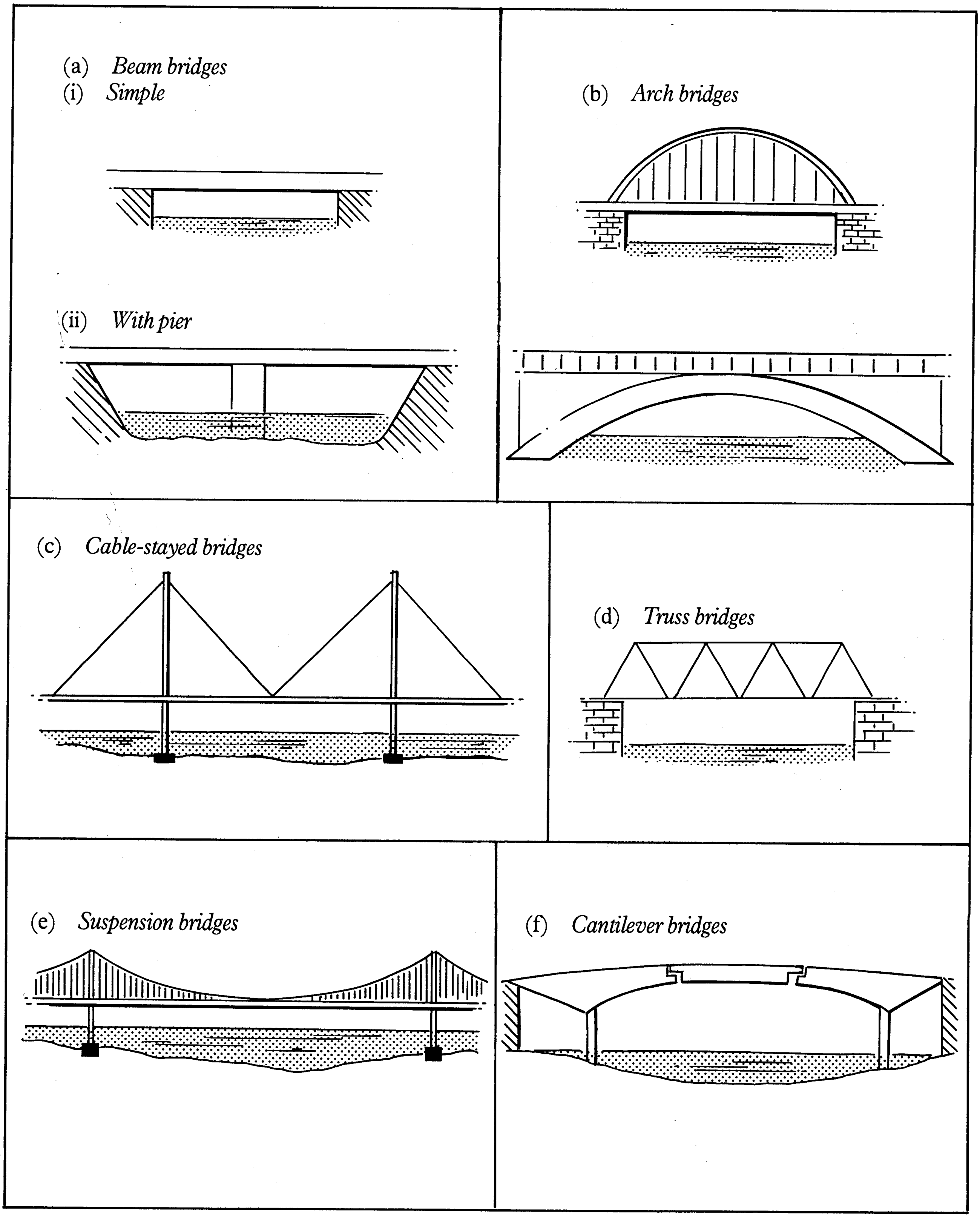


Figure 1 Some of the main types of bridges

Part 1 Looking at bridges

Your teacher may show you some pictures of bridges, or you may make a local survey of bridges.

Draw up a table like the one shown below. As you look at the bridges, fill in the table. The diagrams in Figure 1 should help you decide the type of bridge. If you are not sure of the type, leave the first column blank for the time being.

No.	*What type of bridge is it?*	*What is the bridge made of?*	*What goes over the bridge?*	*What goes under the bridge?*	*Notes*
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

When you have done your survey, you can go on to Parts 2 and 3. These tell you more about the different types of bridges and the materials they are made from.

Part 2 Why are bridges shaped the way they are?

The main problem with bridges is that they tend to bend, like the simple beam bridge in Figure 2.

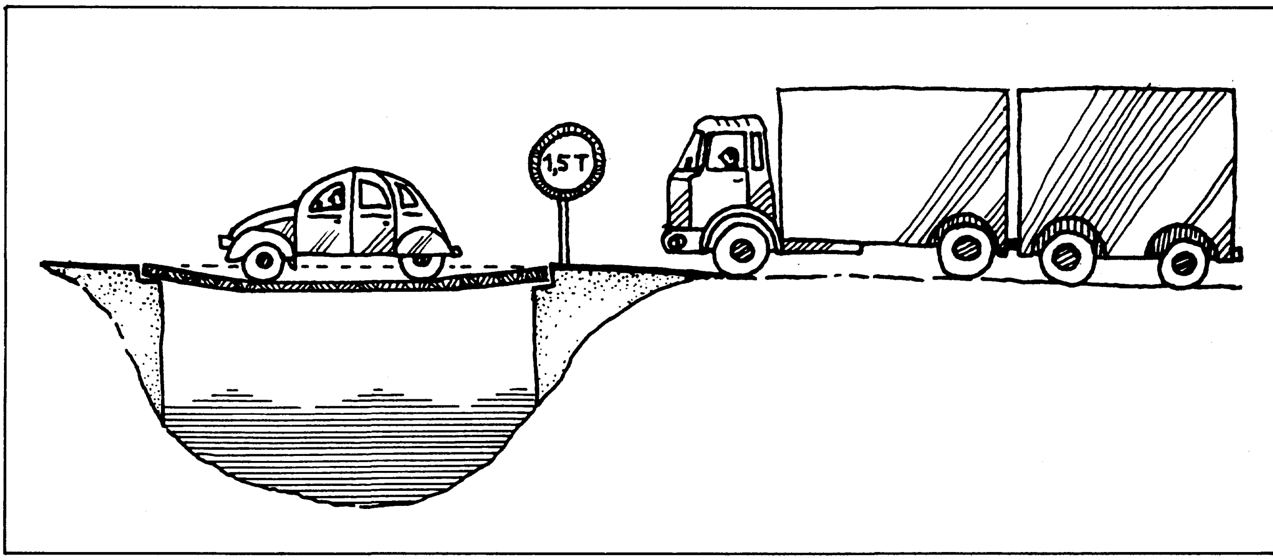


Figure 2 A simple beam bridge bends easily

Bending forces

When something bends, forces are set up in it. Figure 3 shows how the top part has compression forces, which squeeze. The bottom part has tension forces, which stretch.

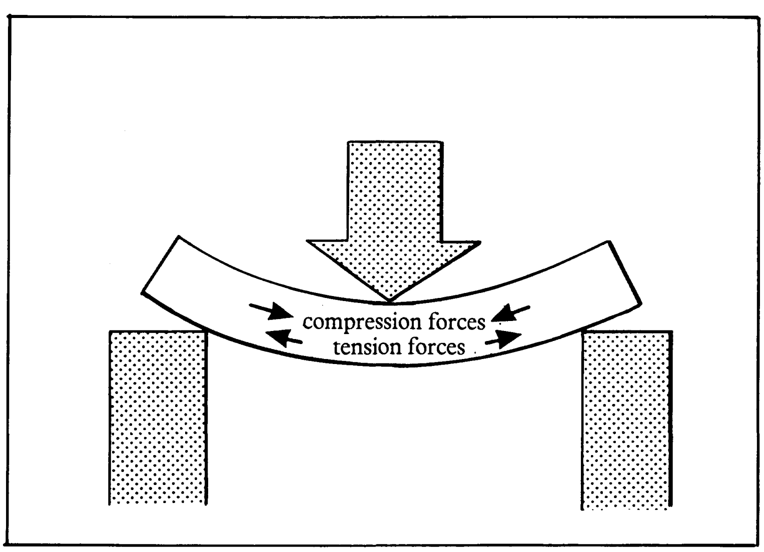


Figure 3 Compression and tension forces in a bending beam

By transferring these forces somewhere else, we can stop the bridge bending too much.

Beam bridges with piers

The easiest way to stop a simple beam bridge bending is to put a pillar (pier) underneath (Figure 4). The pier is easily able to stand the compression forces which are transferred to it.

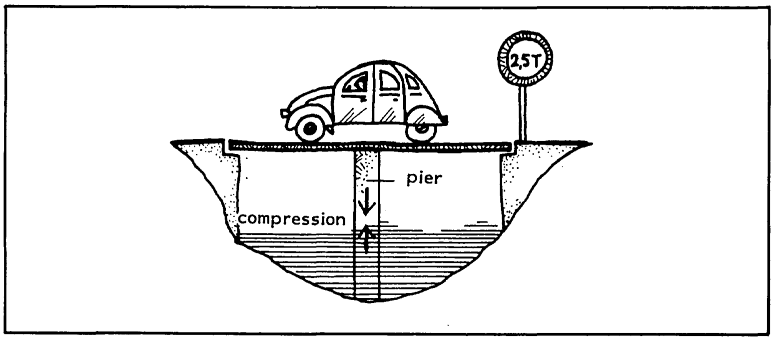


Figure 4

Cable-stayed bridges

Another way to stop a beam bridge bending is to use cables called stays (Figure 5). Tension forces are transferred to the cables, which are strong enough to stand these forces without stretching much.

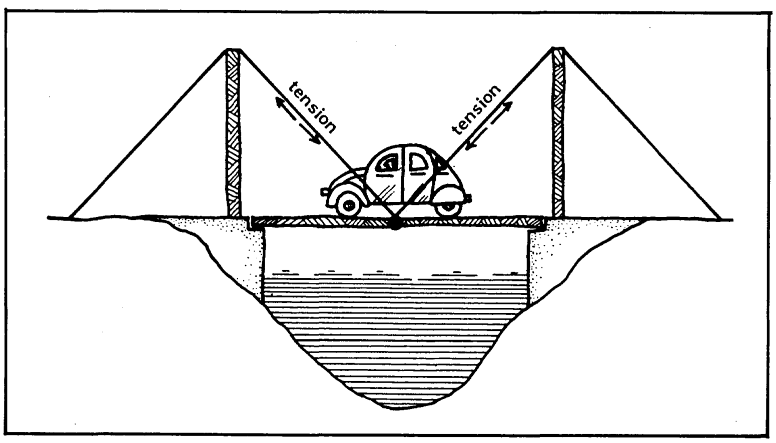


Figure 5

Truss bridges

Truss bridges are designed to transfer compression and tension forces to cross-members. Figure 6 shows the simplest possible truss bridge — most have far more cross-members than this.

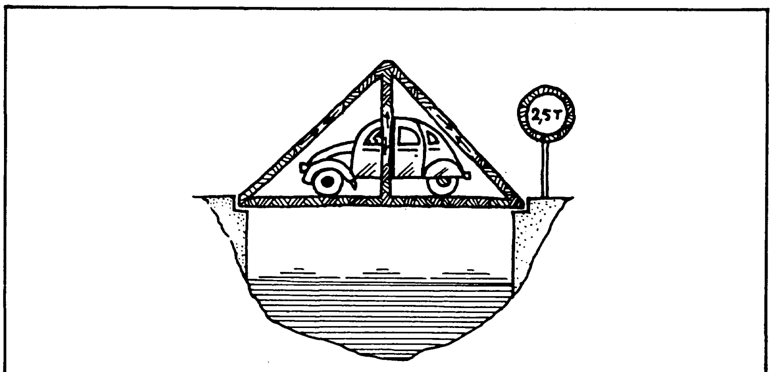
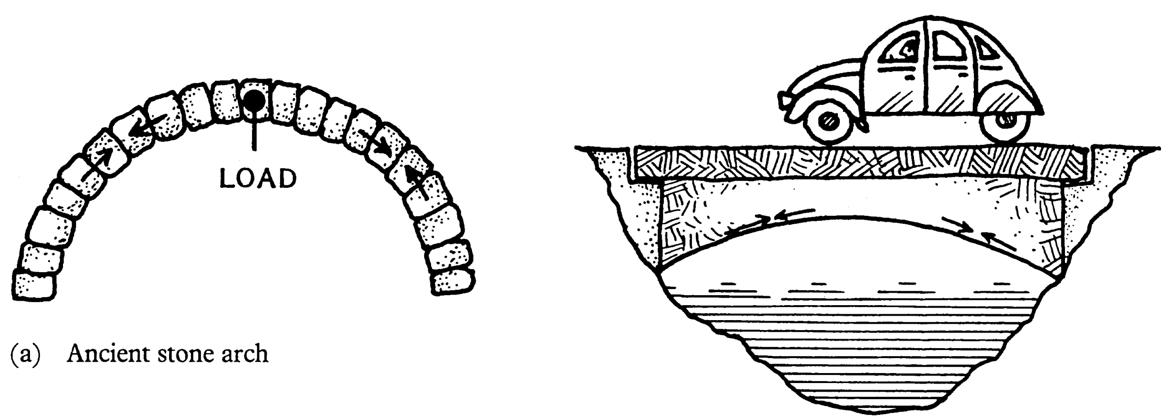


Figure 6

Arch bridges

Some of the oldest bridges are arch bridges. The arch may be above or below the bridge deck, but the general principle is the same in each case. Compression forces are transferred to the arch. The arch in turn transfers these forces to the ground on each side of the bridge (Figure 7).



(a) Ancient stone arch

(b) A modern stone arch

Figure 7 Arch bridges

Suspension bridges

The longest bridges are often suspension bridges.

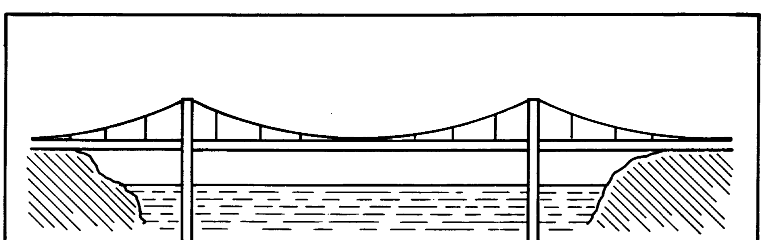


Figure 8

Question

1 Make a copy of the suspension bridge shown in Figure 8. Draw arrows to show the forces acting in (a) the cables; (b) the towers; (c) the deck.

Other types of bridges

There are many other types of bridges, with different shapes and designs. But the general principle of bridge design is always the same — trying to stop it bending.

Question

2 Do you know any other types of bridge, not described here? If so, try to explain how the design stops the bridge bending. Diagrams will help you to do this.

Part 3 What are bridges made from?

Bridges are made from a variety of materials. Which materials are chosen depends on several things, including:

- Cost and availability
- Resistance to fire and corrosion
- Strength.

The most common materials are:

Stone— Cheap and resistant. Strong under compression, but weaker under tension.

Steel— Fairly cheap. Strong under compression and tension. Resistant, but needs maintenance to stop it rusting.

Concrete— Cheap and resistant. Strong under compression, but weak under tension. Can be strengthened by reinforcing with steel rods.

Figure 9 shows a reinforced concrete beam bridge. The reinforcing rod is in the *lower* part of the bridge. This is where the tension forces are. The upper part of the bridge has compression forces, which the concrete can stand.

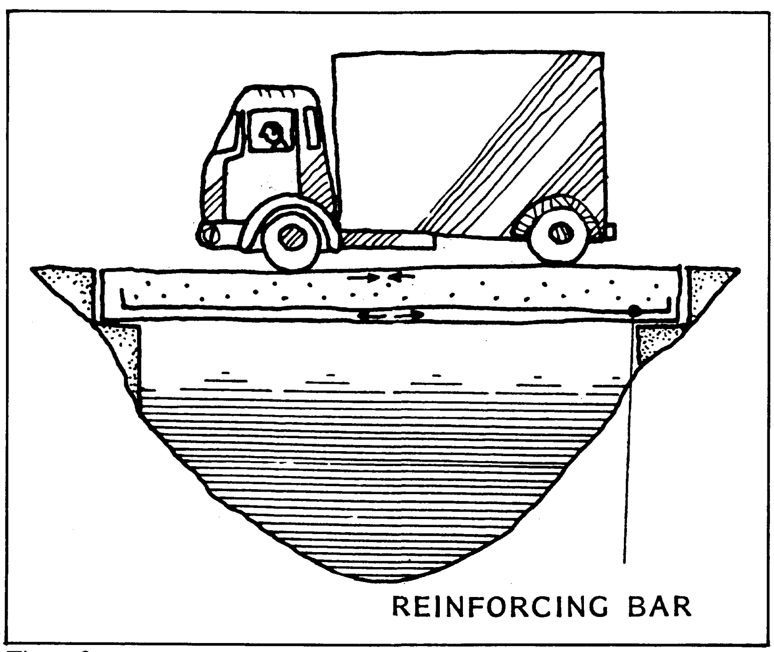


Figure 9

Questions

3 Look at the pictures in Figure 10 below. The reinforcing rod is at the top of the balcony beam, but at the bottom of the floor beam. Explain why.

4 For three bridges you know, try to decide why the bridges were made out of that particular material.

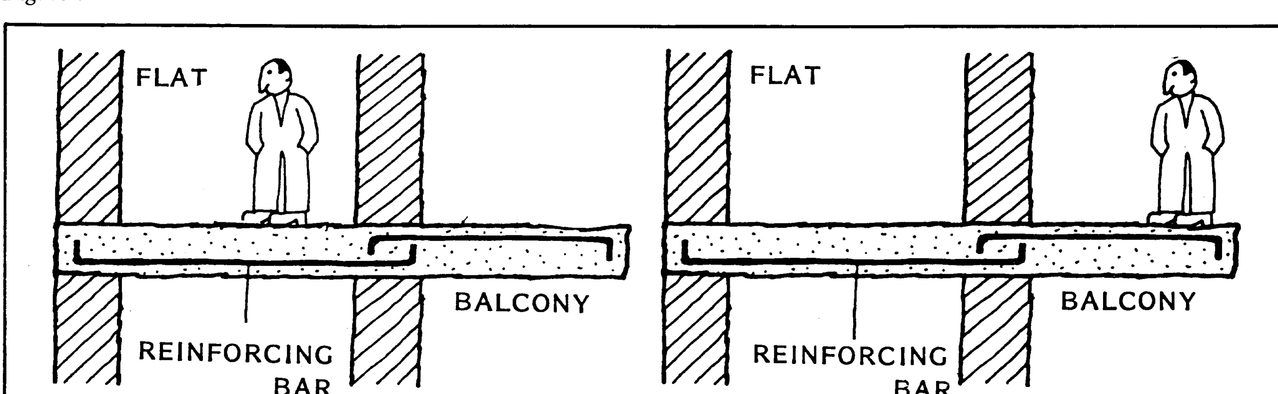


Figure 10

Part 4 Design your own bridge

1 A simple paper bridge

Target:

The intention is to design and build a bridge to carry model cars across a gap at least 25cm wide. The roadway must be wide enough and strong enough to carry two model cars side by side in the middle.

Your bridge should be carefully made and be designed to look good as well as being functional.

Materials:

1 or 2 sheets of A4 paper from which you will make the bridge. Small pieces of sticky tape, or glue, can be used to hold the paper in place, but you must not use them to fix the ends of the bridge to the edges of the gap.

2 A more sophisticated bridge

Target:

The intention is to design and build a bridge which will cross a gap of not less than 50cm. The total mass of the bridge must not exceed 30g. The bridges built by different groups in the class can be tested by hanging loads from the middle of the bridge.

Materials:

Any materials may be used, such as balsa wood, card, paper, string, wire, glue, sticky tape, etc., so long as the total mass of the bridge is not more than 30g. It must be possible to lift the bridge into position and the ends of the bridge must not be fastened to the edges of the gap.