Topic: Structures for Strength

How strong is an egg shell?

http://www.scienceweek.ie/assets/media/Resources/Primary%20Schools/2012%20activities/2012-Science-Week-how-strong-is-an-eggshell.pdf

What happens if you drop an egg onto a hard surface?
That's right, the shell breaks. Is an eggshell always this fragile? Let's investigate.
What you need 4 raw eggs (same size) Pencil Glass Scissors Sheet of A4 paper Ruler Heavy books

What you do

1. Using the pencil, draw a line around the widest part of one of the eggs.
2. Crack the pointed part of the egg. Pour the contents into a glass (you could use these eggs to make a nice healthy omelette).
3. Carefully break off the pieces of the eggshell down to near the pencilled line. Use a scissors to nip off the shell near the line. Try and keep the rim of the shell as even as possible.
4. Repeat steps 1 to 3 with the other 3 eggs.
5. Draw a rectangle on a sheet of paper (about 18 cm by 12 cm).
6. Place one of the egg shells on each corner of the rectangle, with the cut edges facing down, as shown.
7. Carefully place a heavy book on top of the eggshells as shown.

What happens?

The eggs do not crack.

Why?

The halved egg shells under the books are dome shaped. As you can see from the diagram below, a dome is like a number of small arches arranged in a circle.
An arch is strong because its shape evenly spreads the weight on top of it. The weight of the books acting downwards is balanced by the strength of the dome-shaped eggshells. The weight of the books is spread evenly along the curve of the eggshells as shown below.

Note

Arch bridges date back to ancient times, when they were constructed from stone or bricks. Arch bridges are also found in Ireland, for example the famous Ha'penny Bridge (Liffey Bridge) in central Dublin.

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Amazing Triangles

http://www.primaryscience.ie/media/pdfs/col/triangles.pdf

What you need:
Box of cocktail sticks
Bag of marshmallows
mini-marshmallows or any soft sweets.
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Background information
The triangle is a strong shape and is used to support structures. Under a heavy load, a
square distorts easily – it ends up looking like a parallelogram. If you put a brace diagonally across the square, you create two triangles and a much stronger shape. In fact, the triangle is the only shape that cannot be deformed without changing the length of one of its sides. Because it is not easily deformed, the triangle is an extremely popular building shape.

Questions
What shapes do you know?
Can you pick out any shapes in this room?
If you look at a bicycle (or a picture of one) can you pick out any shapes?
What shapes help the bicycle move? (Circles, wheels)
What shapes make the bicycle strong? (Triangles in the frame).
How would you make a corner stronger on a bench or a table?
(Add a strut across the corners to make a triangle.)

Activities
1) Squares and Cubes
(This takes 8 sweets and 12 cocktail sticks).
Take 4 cocktail sticks and 4 sweets. Poke the cocktail sticks into the sweets to make a square with a sweet at each corner. Poke another cocktail stick into the top of each sweet. Put a sweet on top of each cocktail stick. Connect the sweets with cocktail sticks to make a cube.

2) Triangles and Pyramids
(A triangular-based pyramid takes 4 sweets and 6 cocktail sticks). Make a triangle using 3 sweets and 3 cocktail sticks. Poke a cocktail stick into the top of each sweet, and bend these 3 into the centre; now poke them into the 4th sweet to make a pyramid. Now make a square-based pyramid by first building a square base and then 4 triangular sides. Press down on these shapes. Which shape is the strongest?

3) Construction challenge:
(When you make a structure that uses both triangles and squares you can make large structures).

Set the rules: limit the number of cocktail sticks available per person or per pair, and decide on the criteria for winning, e.g. it could be the tallest structure (skyscraper) or the strongest structure (i.e. the one that can take the most weight), the one that most resembles a famous building such as the Eiffel tower, etc. A time limit may be set if you wish.

Safety
Careful with points of cocktail sticks.

Follow-up activities
Look up pictures of different structures – e.g. bicycles, Eiffel Tower, truss bridges, etc. Can you find triangles in them? Can you make strong structures with straws and split pins/ paper fasteners?

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Design a bridge

http://www.primaryscience.ie/media/pdfs/col/dps_maths_bridges_activity.pdf

Find a context where children have to think about crossing a river. This might be a story or a local river crossing. Find out what children think and know about bridges. They may mention tunnels as well as a means of getting across.
Have a display of pictures of bridges.
Visit a local bridge.
Do this introductory work on the day prior to doing the activity.

Questions
What is a bridge?
Where would you find bridges?
What are bridges made of?
What makes a good bridge?
What types of bridges are there? Can you name any?
(Bridge designs include arch, suspension etc.)
Can you find out about the tallest bridge in the world, opened in December 2004?
Ask the children to draw a bridge they know or have crossed. They can count how many bridges (if any) they meet on the way home.

Activity 1
Place two piles of books the same distance apart on each table.
Make different kinds of bridges between the books and test which ones are strongest.
e.g. make a simple bridge using 1 page of A4 paper. Test its strength by adding coins or other masses.

Activity 2
Design a Bridge
Explore how to make a paper bridge stronger
Using the blocks or books, paper and coins, design a bridge that will take the heaviest weight.
Try the following and record the results:
1) Make a bridge from one piece of paper and test its strength by adding coins or other masses until the bridge collapses.
2) Use two pieces of paper and test again.
3) Use one piece of paper and fold up sides, i.e. a walled bridge
4) Make an arch (using two pieces of paper).
5) Make a corrugated bridge, (folded like an 'accordion' or paper fan.
6) Make a bridge out of a different material.

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Design a catapult

http://www.primaryscience.ie/media/pdfs/col/Design_a_catapult_activity.pdf

What you will need:

1. For Upper primary:

For each catapult:
14 lollipop sticks,
1 rubber band,
sellotape,
1small piece of paper (approximately one quarter A4 sheet).

2. For Middle Primary:

For each catapult:
1 bulldog clip
short ruler (15 cm.)
1 thick rubber band
small piece of paper (approximately one quarter of an A4 sheet)

Preparation:

Ideally, should have learned about the strength of the triangle. (See Structures for Strength, Amazing Triangles.)

Information:

• When a force acts on an object that cannot move, it may change its size or shape.
• Some things (e.g. plasticine/ modelling clay) stay in the new shape when the force is removed. But some substances, like rubber, return to their original form when the force is removed. The latter are called ELASTIC substances.
• Elastic materials store energy when they are stretched, and release the energy when the force is removed. So energy is stored in stretched rubber bands (this is the energy which you have put into it to stretch it). This energy is released when the rubber band is let go and it goes back to its original size.
• Elastic things will not stretch forever! They will snap if you stretch them too far.
• This activity also shows the strength of the triangle. The triangle is a shape often used in architecture because of its strength. (See Structures for Strength 'Amazing Triangles').

Questions:

What do you use rubber bands for?
What is the advantage of rubber bands over a piece of string?
(They stretch).
When you stretch a rubber band what does it do? (It gets longer).
When you let it go again what does it do? (It goes back to its original size).
Do you think a trampoline is elastic? (Yes!)
What happens to a trampoline when you jump on it?
(It stretches downwards).

Then what happens? (It goes back to its original shape, releasing the stored energy and pushes you up in the air)

Activity:
The children should be given some rubber bands to play with and explore their properties carefully. (Thickness, stretchiness, etc.)

Upper Primary:
Make a triangular-based pyramid using the lollipop sticks.
Then make the arm of the catapult, using 2 lollipop sticks.
Attach the arm to the pyramid as follows:
Wrap one end of the rubber band around one end of the catapult arm about 1 or 2 cm. from the end. Then attach the other end of the arm to the base where the three triangles meet. Secure this firmly with tape (which acts as a kind of hinge).
Lastly, attach the other end of the rubber band to the top of the catapult.
Now roll up the piece of paper into a tight ball and fire! (by placing the paper on the arm just above the rubber band, pulling back and then letting go. You will need to hold the base with the other hand.)
Measure the distance the paper travelled.
This can be done a number of times, the distances recorded and the average distance taken.

Various distances and heights of the paper bullets can be measured.
Experiment with various angles of the arm to see how to get the longest distance?
The length of the arm, the length and strength of the rubber band can be varied, data should be recorded and any conclusions drawn.

Middle Primary:
A ruler catapult can be made by attaching the bulldog clip to the end of the ruler and then attaching the rubber band to the clip.
Pulling back the rubber band puts energy into it; putting a tightly-rolled ball of paper into the end of the rubber band, and then letting it go, releases this energy very quickly, and the paper may go shooting off.
This should be tried a few times, investigating at which angle the ruler was held, how far the band was pulled, what length rubber band gave the longest distance etc.
The distance the paper travelled should be measured and recorded. This should be done a number of times and the average taken.

Safety:
Although paper is soft do not aim the ‘bullets’ at children as it could frighten them.

Follow-up activity:
There are a large number of ways in which the principle of stored energy is used to make catapults.
The children should be encouraged to design and make their own catapults.
They could try using a piece of eggbox as a holder for the paper ball.
They could try using rolled-up kitchen foil instead of the paper ball.