

Testing rocks 3 – that shrinking feeling Investigating shrinkage in clay as it dries out

Clay may become more plastic when it gets wet (see Earthlearningidea Testing rocks 2 – “Splat!”), but what happens when it dries out? Could this cause a problem for buildings?

Take a clay sample and gradually add enough water to make it very plastic (you could use the final clay from the “Splat!” test). Pack the clay into a rectangular box, making sure that there are no air pockets, and level off the top surface of the clay, flush with the top of the box, using a ruler or a thin wire.

Weigh the box of clay and record the results. Discuss what you expect to happen after a few days – to the mass of the clay and to its size. Leave it in a warm place, e.g. in the sun or near a radiator, for a few days and then weigh it again and record the results.

Has the mass decreased, increased or stayed the same? Try to explain your answer.

Now carefully tip the block of clay out of the box and measure its length, breadth and height in centimetres. Find the volume of the clay block (in cm^3) by multiplying these figures together. Find the volume of the box itself, (in cm^3) by measuring its internal length, breadth and height and multiplying these figures together.

The volume of the box is the same as the volume of the original damp clay, so we can find the loss in volume when it shrank by the equation: change in volume of clay = volume of box minus volume of clay.

Calculate the percentage change in volume using the equation:

$$\frac{\text{change in volume of clay in cm}^3}{\text{original volume of box in cm}^3} \times 100\% = \dots\%$$



Shrinkage cracks in a dried out lake bed (the bag is 10cm long)

(Photo: Peter Kennett)



The collapse of the Holbeck Hall Hotel, Scarborough, Yorkshire, in 1993. (BGS photo ID 10741/1).

The back up

Title: Testing rocks 3 – that shrinking feeling

Subtitle: Investigating shrinkage in clay as it dries out

Topic: Pupils investigate the percentage shrinkage of damp clay when it dries out and relate this to potential engineering problems.

Age range of pupils: 14 – 18 years

Time needed to complete activity: 20 minutes to set up, 20 minutes again a few days later.

Pupil learning outcomes: Pupils can:

- make measurements, whilst understanding that they may be approximate;

- make predictions, based on their own experience, about the likely outcomes of allowing clay to dry out;
- suggest other factors which might influence the engineering properties of rocks in practice.

Context: Civil engineers and house builders need to take into account many different properties of rocks, of which the shrinkage of clay is one important factor. We investigate others in other Earthlearningidea activities. In answer to “*Discuss what you expect to happen after a few days – to the mass of the clay and to its size*”, pupils will mostly realise that the mass will decrease because of evaporation of water from the clay and that it will shrink, so that its volume will decrease.

Following up the activity:

Pupils could:

- be shown photographs of buildings affected by the shrinkage of clay, e.g. the collapse of the Holbeck Hall Hotel in Scarborough in 1993;
- investigate other engineering properties of rocks, through further Earthlearningidea activities;
- make a field visit around their own school grounds, looking for evidence of clay shrinkage, or trees planted too close to neighbouring houses, whose roots might cause the drying out of clay subsoil, using the note below - *On clay soils it is best to avoid planting trees nearer to your home than a distance equal to three-quarters of the mature height of the tree. However, high water demand trees should be planted no closer to the home than one and-a-quarter times the mature height. High water demand trees include elm, eucalyptus, oak, poplar, willow and some common cypress species.* (from "A guide to your new home", National House Building Council (www.nhbc.co.uk)).
- invite a local civil engineer or engineering geologist to speak at their school about the importance of understanding the geology before carrying out a new project.

Underlying principles:

- Clay is a surprisingly porous material.
- All clays shrink when water is lost.
- Water may be lost by drainage, by long spells of very dry weather or by nearby tree roots abstracting water from the ground.
- Abstraction by tree roots accounts for more shrinkage in clays than variations in rainfall (NHBC Guidelines)
- To some extent, some water in a clay helps to give it strength, by pore water pressure, and this is reduced when the clay dries out.
- Successive wetting and drying may be a more potent cause of failure of clay than one phase of drying out alone.
- The Holbeck Hall Hotel was built on glacial "boulder clay". This is thought to have shrunk and cracked in dry weather, so that water was able to penetrate more quickly when a prolonged wet spell followed. This increased

the pore water pressure too much and resulted in failure of the slope beneath.

- Engineers recognise two types of clay:
 1. normally-consolidated clay where the compression caused by the structure is the greatest the clay has experienced. The "boulder clay" at Holbeck Hall is of this type.
 2. over-consolidated clay where the clay has been highly compressed by thick overlying rock sequences which have later been eroded away. Clay of this type has had water driven out leaving micro-fissures which allow a degree of drainage. London Clay is of this type.

Movement due to structural loading is generally smaller on over-consolidated clays than on normally-consolidated clays.

Thinking skill development:

Thought processes of 'construction' are involved in collecting data.

Some clays may not shrink as much as pupils expected, involving cognitive conflict.

Applying lab work to the real world of engineering involves bridging.

Resource list: per small group of pupils:

- a small rectangular container, such as a small plastic chocolate box
- enough soft clay to fill the container: water-based art clay or garden clay
- water
- ruler (or thin wire)
- access to a balance

Useful links: See the E-library of the National Science Learning Centre for a full version of "Routeway" -

<http://www.nationalstemcentre.org.uk/elibrary/resource/737/routeway-solving-constructural-problems>

Source: Based on an original unit, "Routeway 1 – a testing time for rocks" written for the Earth Science Teachers' Association by Peter Kennett, Julie Warren and Laurie Doyle. Thanks are also due to Martin Devon for engineering advice.

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