Testing rocks - 1 bouncing back
Testing the strength of rocks

When engineers build structures such as dams, roads and tunnels, they need to investigate the properties of the rocks beneath and around them. One of the key properties is the strength of the rocks. This normally requires expensive equipment, but we can get quite a good idea by simply dropping a ball bearing onto a flat, cut sample of the rock. The height to which the ball bearing bounces back allows us to compare the relative strength of different rocks.
Give pupils a range of cut samples of rocks, obtained, for example, as off-cuts from worktop manufacturers, demolition contractors or builders' suppliers. Ask each group to drop a ball bearing onto each rock in turn, from the "100cm" mark on a metre rule resting on the rock slab. Pupils measure the height of the rebound against the metre rule, and record the result. 'Best practice' involves taking at least five measurements from each rock and calculating the average rebound height.
Ask them to draw a bar graph of their results and to state which rock is the strongest (highest rebound) and which the weakest (lowest rebound). If a clear plastic tube is available, the ball bearing may be dropped down it onto the rock, so you don't have to chase elusive ball bearings across the room!

Students using a Schmidt Hammer to measure the strength of a limestone, as part of a tunnel planning exercise

An unsupported tunnel in limestone, dug by copper miners in 1804 (All photos: *Peter Kennett*)

Students testing the rebound of a ball bearing from a rock sample (using a 2m long plastic tube)

The back up

Title: Testing rocks 1 - bouncing back

Subtitle: Testing the strength of rocks

Topic: Pupils investigate the relative strength of several rocks by dropping a ball bearing onto flat, cut surfaces of rock samples.

Age range of pupils: 14 -18 years

Time needed to complete activity: 30 minutes

Pupil learning outcomes: Pupils can:
- acquire manual dexterity in handling rock samples and a lively ball bearing;

- take measurements, whilst appreciating that the speed with which they must make the observations may involve errors;
- discuss the relative merits of their samples;
- suggest other factors which might influence the engineering properties of rocks in practice.

Context: Civil engineers need to measure many different properties of rocks, with the strength being one important factor. We shall investigate others in future Earthlearningidea activities.
Some typical mean values for the strength of some dry rocks are shown in the table. It must be stressed that these are guideline figures only.
Rocks which are saturated with water are usually weaker.

Rock group	Rock type	Strength (MPa)
Igneous	granite	200
	basalt	250
Metamorphic	gneiss	150
	slate	90
Sedimentary	hard sandstone	180
	soft sandstone	20
	hard limestone	100
	chalk	15
	clay	2

Following up the activity:
Pupils could:
- test whether the samples they have available produce a lower or a higher ‘bounce’ if saturated with water;
- be shown photographs of road cuttings, tunnels, dams or bridge piers and asked to consider what other factors may need to be taken into account in planning such structures;
- investigate other engineering properties of rocks, through further Earthlearningidea activities;
- make a field visit to a local engineering project to study how possibly unstable surfaces are stabilised;
- 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:
- There is a statistical correlation between bounce height and rock strength.
- “Rock strength”, as used here, is a shortened version of “the uniaxial compressive strength of a rock”, measured in megapascals.
- Engineers would use equipment such as a Schmidt Hammer, (see photograph), which uses a rebound measurement to obtain the uniaxial compressive strength.
- The strength is also dependent on the density of the rock, and rebound measurements are related to the density before a value in megapascals can be allocated.
- The strength of the crystalline limestone in the tunnel of 1804 in the photo is about 120MPa.
- Rocks are relatively strong in compression, e.g. when bearing the load of a road surface, but weak in tension, e.g. in the roof of an unsupported tunnel.

Thinking skill development:
Thought processes of construction are involved in collecting data and drawing a graph.
Some rocks may not be as strong as pupils expect, involving cognitive conflict.
Applying lab work to the real world of engineering involves bridging (in more than one sense!)

Resource list: per small group of pupils
- a range of flat cut samples of rocks, preferably all of the same thickness; these are often provided free of charge by work top manufacturers, demolition contractors or monumental masons
- ball bearings, e.g. of about 5mm diameter
- a metre rule
- (optional) a clear plastic tube, such as those that roller blinds are sold in
- graph paper

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-constructional-problems
See a virtual version of this activity at:
http://www.esta-uk.net/virtexpts/rock/index.html

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.