Sandcastles and slopes
What makes sandcastles and slopes collapse?

Ask pupils if they have ever made a big sandcastle. What was the steepest angle they could build the side walls of the castle? Could they make a steeper wall if the sand was dampened?
Questions like these go well beyond the playground or beach. Many people have been killed by the collapse of unstable slopes of loose rock or sand.

How to measure the angle of rest of dry sand. (Note: It is easier to use the protractor as shown, with the 90^{o} line running vertically, than with the zero line of the protractor resting on the table top).

Encourage pupils to find out the angle of rest of dry sand as follows.

Give them a glass or plastic jar half-filled with dry sand. Ask them to:

- lie the jar horizontally on the table and roll it around until the sand is packed evenly;
- position the jar so that the top surface of the sand is horizontal;
- roll the jar gently until the sand just starts to slide down;
- use a protractor to measure the angle from the horizontal of the top surface of the sand;
- repeat the investigation five or six times and calculate the average angle. This is the average ‘angle of rest’ of dry sand.

Ask pupils what difference it might make if they were to use different materials, such as coarser sand or gravel. Repeat the activity using these different materials.

A scree slope, where frost-shattered limestone blocks have fallen down the slope. The largest blocks are at the base of the scree, since their momentum has carried them further. (*Photos: P. Kennett*)

Finally, ask pupils to say what difference it would make if they were to dampen the sand and other materials. Then ask them to investigate their predictions, with the original materials in the jar.

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The back up

Title: Sandcastles and slopes.

Subtitle: What makes sandcastles and slopes collapse?

Topic: Investigating the factors which affect the angle at which loose materials rest before they begin to slide.

Age range of pupils: 11 - 18 years

Time needed to complete activity: 30 minutes if several variables are tested

Pupil learning outcomes: Pupils can:

- measure angles with reasonable accuracy in an unfamiliar situation;
- take a series of measurements and calculate an average value;
- observe the movement of loose materials as the slope angle is increased;
- predict the effects of changing variables during the investigation;
- explain why slope failure can occur and why it may be hazardous.

Context: The activity could form part of a lesson looking at the mechanism of sediment movement.

It could lead to an understanding of the role played by slope failure in the formation of scree slopes. It may also enable pupils to appreciate the dangers of living in areas with steep slopes, or of playing in workmen's trenches which have been left with no support.

Following up the activity:
Pupils could repeat the investigations, but this time they could fill the remaining space in the jar with water, to see how slope failure under water compares with that on dry land. Some may realise that displacement of large volumes of material under water, or into a mass of water, could cause an additional hazard in the form of a tsunami wave. It is thought that a prehistoric slide about 8000 years ago off the Norwegian coast (the Storegga Slide) triggered a tsunami which inundated the shores of the North Sea.

Try other Earthlearningidea activities dealing with related themes, e.g. 'A landslide through the window'; 'Dam burst danger'.

Underlying principles:
The stability of a slope and the angle that can be sustained in loose materials depends on several factors. These include:

- the packing of the grains together – loosely packed grains do not support each other as well as tightly packed ones, so the slope will be less on the loosely-packed materials.
- the shape of the grains – elongated grains can interlock more readily than equidimensional ones, which increases the stability of the slope.
- the smoothness of the grains – there is more friction between rough grains, which will sustain a greater slope than smooth grains.
- the amount of water present – a little water produces greater cohesion between the grains, allowing for steeper slopes. However, more water may act to reduce friction by buoying up the grains and reducing the friction between them.

There is often surprisingly little difference in the maximum slope angle when the same materials are tested dry and then under water. A maximum angle of about 34^{o} is usually quoted.
Where larger materials are involved, such as boulders on a scree slope, their momentum may carry them far from the source, once they have begun to move on the slope.

Thinking skill development:
Investigating the movement of the loose materials is a constructive activity. Cognitive conflicts arise when pupils find that their measurements are not what they expected. Explaining their results involves metacognition. Applying the investigation to real slopes requires bridging skills in pupils' thinking and may have an impact on their daily lives in some locations.

Resource list:

- an empty glass or plastic jar with a screw top lid
- some dry sand
- a variety of other loose dry materials, e.g. sand of a different grain size, gravel, or even foodstuffs such as lentils, dried peas
- protractor
- water

Useful links:
http://www.throughthesandglass.com This personal website describes the outcome of combining two different sets of grains in one transparent container.

Source: Adapted from an idea by Simon Elsy and published by the Earth Science Teachers' Association (1988), *Science of the Earth, 'Moving Ground'*, Sheffield, Geo Supplies Ltd.