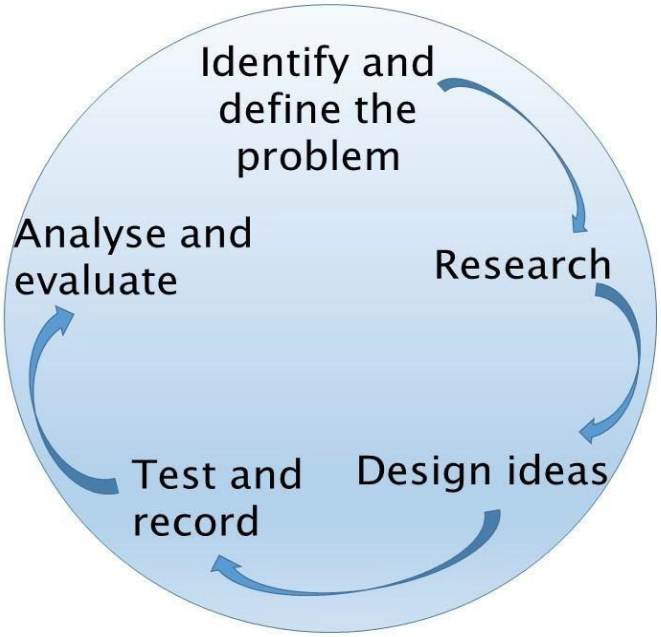
Landslide Engineering – Student Workbook

How to use this document

1. Open this file in Adobe Reader. If you do not have this program you can download it for free here: https://acrobat.adobe.com/au/en/acrobat/pdf-reader.html
2. Download the file and **save** it to your computer as Project Name _Your Name e.g. Going for Gold_Joe Bloggs. **It is really important you do this otherwise none of your input will be saved.**
3. Fill in your answers in the spaces provided in the document.
4. Where there are image boxes take photos or scans of your work and upload the picture file. If you cannot do this, for any reason, upload the pictures as separate files and save them as Project Name_Your Name_Image number e.g. Going for Gold_Joe Bloggs_Image 1.
5. Save your work as you go along.
6. When you have finished email or upload your completed document (and image files) as your teacher has instructed.

The Challenge

Landslides can have devastating impacts, they can move and destroy roads, rail and cars, and even topple buildings. Your role is to investigate some causes of landslides and suggest methods to prevent damage from these events.



Background Information

What pulls you towards the ground when you are at the top of a slide? The answer is gravity. You have probably noticed that when you wear different clothes you might go down the slide faster or slower. This is because of friction. Reducing friction will make you move faster down a slide. Land can move for the same reasons. When land moves down slope it is known as a landslide.

Landslides can be triggered by earthquakes, volcanoes, heavy rain and even large vibrations from machinery or building work.

In 1997, a catastrophic landslide occurred in Thredbo, New South Wales. The slope above two ski lodges became unstable and just over 100 tonnes of liquefied soil slipped downhill. This destroyed two ski lodges. Witnesses reported hearing a whoosh of air, a crack and a sound like a freight train rushing down the hill. There were 18 fatalities and only one survivor from the lodges.

Figure 1. SES volunteers and firemen assisting at the Thredbo debris slope in 1997.

It can be difficult to study landslides, as scientists and engineers usually don't know when they will happen, however, scientists can use models to help make predictions about where one might occur and what might cause it. Engineers can use debris flow flumes to recreate landslides on a smaller scale so they can study them. They can use their understanding of landslides to assist them to come up with ways to either stop them from happening, or at least stop them from causing too much damage.

Background Research

Using the links below, answer the following questions:

- https://www.usgs.gov/faqs/what-a-landslide-and-what-causes-one?qtnews_science_products=0#qt-news_science_products

  https://science.howstuffworks.com/environmental/earth/geology/landslide3.htm

1. What is a landslide?

2. What are the five modes of slope movement?

3. List three factors which may initiate landslides on slopes which were already on the verge of movement.

4. What is the name given to a landslide in the ocean, and what can they trigger?

5. How can wildfires lead to landslides?

6. What is a lahar?

7. What human activities add to the likelihood of landslides occurring?

Finding the Angle of Repose

Background

You've probably been to the beach or sandpit and made a sandcastle or two in your life. Sometimes the sandcastles look more like big domes than castles as it is hard to maintain steep sides. The steepest angle at which a sloping surface is still stable (does not collapse) is known as its angle of repose. This angle can be anything between $0^0 – 90^0$, and it will depend a lot on the material. For example, smooth, rounded grains will slide past each other much more easily than jagged grains.

Objective

To determine the angle of repose for a range of different materials.

Equipment

- 1 bag of very fine sand
- 1 bag of course sand
- 1 bag of gravel
- 1 bag of small rocks
- 1 piece of cardboard
- 1 pencil
- 1 protractor
- 1 plastic tray
- Newspaper

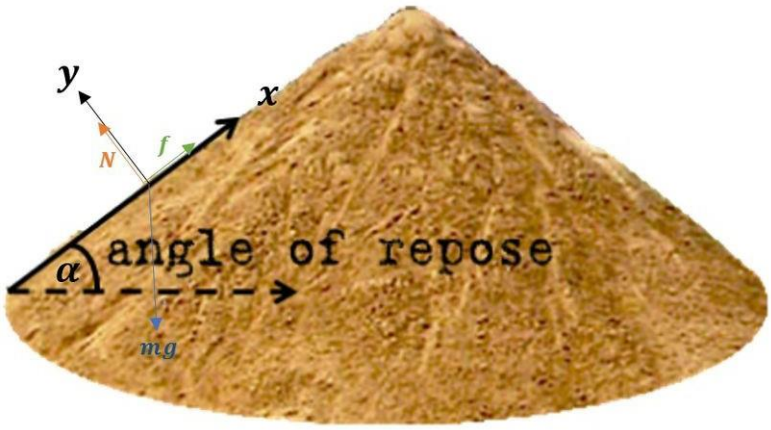


Figure 2. The angle of repose on a sand castle is the steepest angle the sand will remain at before collapsing.

Method

1. Line the tray with a piece of newspaper and pour some of the fine sand into it. Build a sand castle making the sides as steep as possible.
2. Push the piece of card through the middle of the castle, making sure it is upright, and mark on the card the edge of the sand castle (as shown in the picture below).
3. Remove the piece of card and measure the angle of repose using the protractor, recording it in the results table.

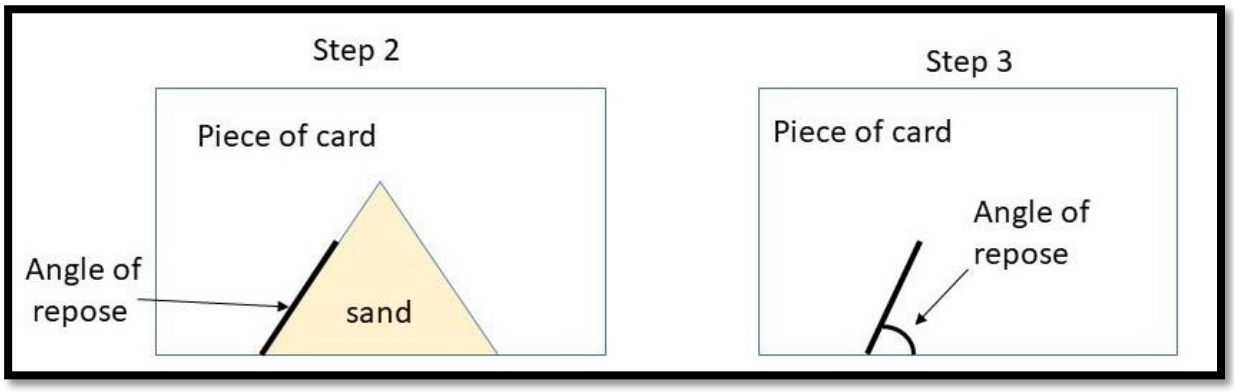


Figure 3. Mark on the edge of the sandcastle then measure the angle using a protractor.

4. Pour the sand back into the bag carefully, using the newspaper like a funnel.
5. Repeat steps 1- 5 for each material.

Results and Analysis

Material	Angle of repose
Fine sand	
Course sand	
Gravel	
Small rocks	

1. Order the materials used from lowest to highest angle of repose.

2. Which material allowed you to create the steepest slopes (had the highest angle of repose)?

3. Which material had the lowest angle of repose?

4. Which material would be most likely to slip (be part of a landslide)? Explain your answer.

Evaluation

1. Was this a fair test?

2. What could you do to improve this test?

Effect of Water on Slope Stability

Background

Everyone knows when you want to build a great sandcastle you use the wet sand from close to the shoreline, right? But does it matter how wet the sand is, or is it a case of the wetter the better? Water can help stick the sand together, but it will also make it heavier and can reduce friction.

Heavy rain can quickly saturate soil which is on top of hard rock. This investigation simulates what happens when soil becomes waterlogged.

Objective

To determine the impact of water on slope stability.

Equipment

- 1 x plastic tray
- 1 x plastic piping cut in half, about 50 cm long
- 1/2 x cup full of sand
- Measuring beaker (or container that can be used for measuring)
- Protractor
- Duct tape

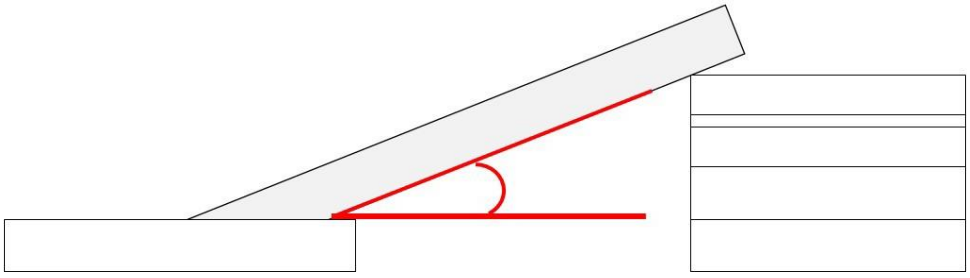


Figure 4. Measure the angle marked in red using a protractor at the point the sand starts to slide.

Method

1. Duct tape one end of the piping into the tray to secure it in place.
2. Empty the sand onto the other end of the piping.
3. Slowly raise the end the sand is piled on, creating a slope, until the sand starts to slide.
4. Hold the pipe steady (or use books to prop it up) at the angle where the sand just starts to move and have another group member use the protractor to measure the angle between the tray and the piping (marked in red on the picture).
5. Pour the sand back in the cup and add 50mL of water to it.
6. Repeat steps 2-5 four more times.

Results and Analysis

Volume of water added (ml)	Angle at which the sand starts to slide (^{0})
0	
50	
100	
150	
200	

1. Graph your results and insert a photo in the box below.

2. Compare your results to other groups, do they follow a similar trend?

3. What effect does adding water have on the angle at which the sand starts to slide?

4. What does this investigation suggest will happen to slope stability if there is heavy rain? Use your data to back up your answer.

Plant Power

Objective

To investigate the impact of vegetation (plant) cover on the chance of a landslide occurring after heavy rains.

Equipment

- 1 half drain pipe
- 1 tray
- Potting soil
- Small established plant in soil
- Measuring jug
- Duct tape
- 1 cup
- Some thick books

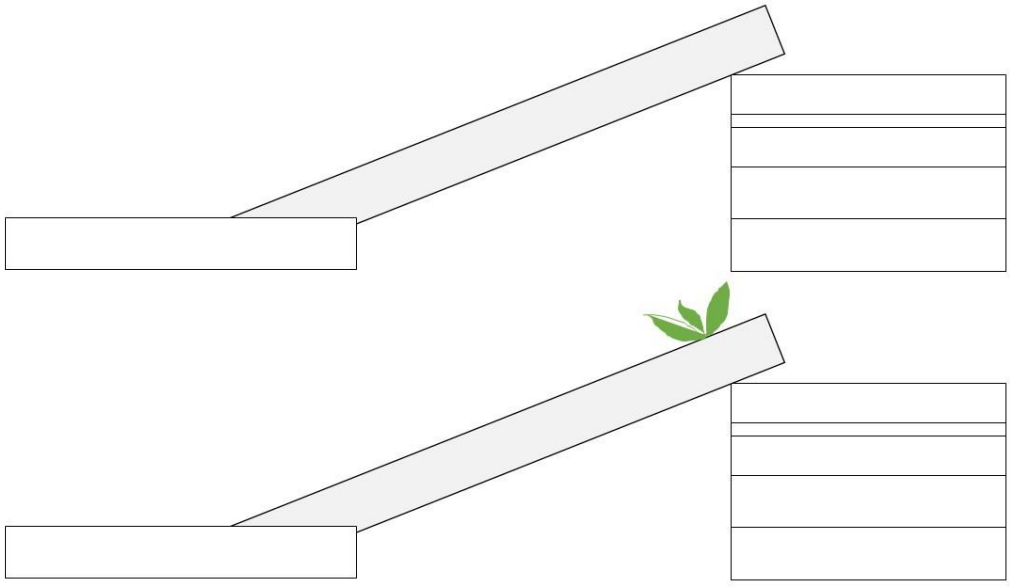


Figure 5. Top picture shows the drainpipe resting on books/blocks to give elevation, lower picture shows plant in soil at the top of the sloped pipe.

Method

1. Tape one end of the pipe into the centre of the plastic tray
2. Raise the other end of the pipe up and place it on a stack of books, so that it is now sloping.
3. Put one cup of soil at the top of the pipe.

4. Collect 500ml of water in the jug.
5. Slowly pour the water on top of the soil and observe what happens, recording your observations.
6. Empty out the soil and wash up your equipment.
7. Repeat the investigation, this time with the plant in the soil at the top of the slope.

Results and Analysis

1. What happened to the soil in the first trial of the experiment?

2. What happened to the soil with the plant in it (second trial)?

3. Explain what you think caused any differences in the trials.

Animating Undercutting

Background

One cause of landslides is the undercutting of rocks. This happens near the beach where waves weather and erode cliffs. The removal of the rocks underneath makes the overlying rocks unstable and added weight can make them crumble. This is known as a topple.

Figure 6. Sign warning of possible topple on unstable cliffs.

Objective

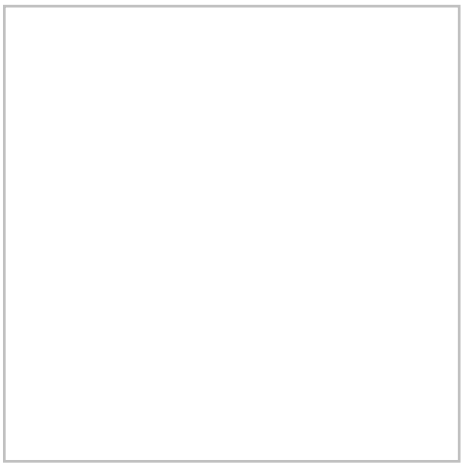
To make a stop-motion animation demonstrating how the removal of supports can lead to landslides.

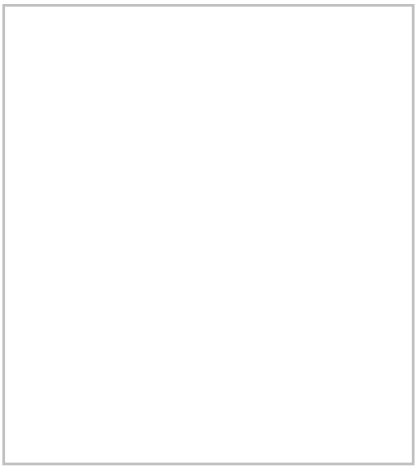
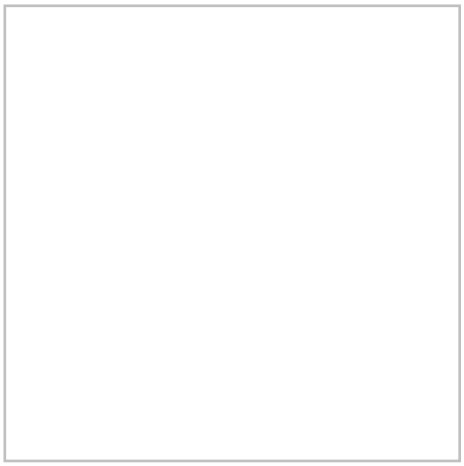
Suggested Equipment

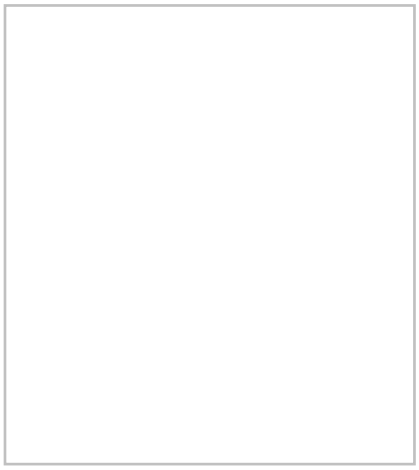
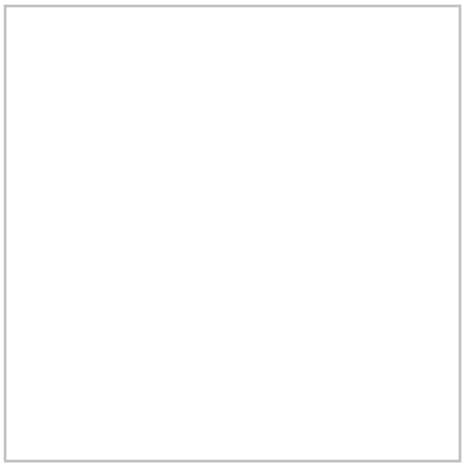
- Camera/iPad
- An iPad or computer with a stop motion animation program installed
- Lego/Duplo/Jenga blocks/clay/ plasticine or any other material available to you
- Tray with water

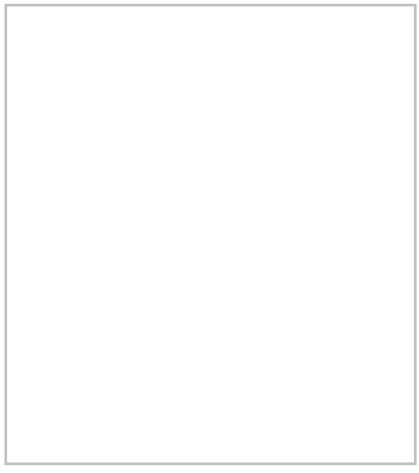
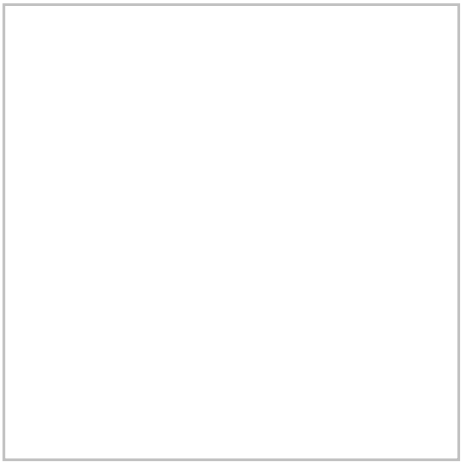
Method

Use the camera or iPad to take a series of photos to show what happens when the rocks at the base of a cliff are eroded away, leading to a topple. Add these to the boxes on the next page.


An initiative supported by Woodside and ESWA

Evaluation

Does your animation represent a topple well?

What could you do to improve it?

Engineering a Solution

Objective

To research a range of engineering solutions to prevent landslides and decide which solutions would be best in a range of scenarios.

Method

Research a range of engineering solutions to stabilise slopes and complete the table below.

Method	How it works	Diagram
Drainage		
Retaining walls		
Rock bolts		
Revegetation		

Suggested sites:http://www.sinaiconstruction.net/LA-foundation-retrofit-blog/slope-failure-repair-options/ https://en.wikipedia.org/wiki/Retaining_wall and https://www.britannica.com/technology/rock-bolt

Analysis

1. Which method of slope stabilisation would you recommend for sand dunes? Explain your answer.

2. Which slope stabilisation method would you use for steep cliffs above a road, like the picture below? Explain your answer.

Figure 7. Steep road cutting along a mountain path.

3. Which method would you use if you wanted to grow crops on a steep hillside? Explain your answer.