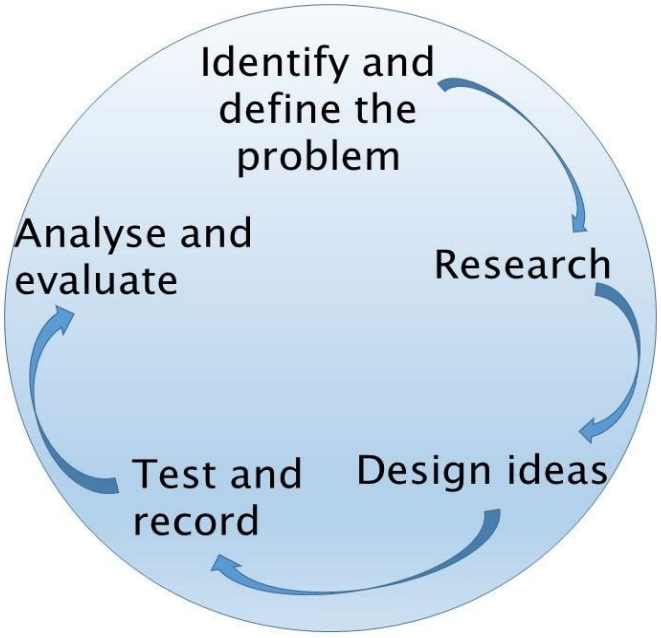
Landslide Engineering – Student Workbook

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

Use a range of sources to answer the questions below.

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.

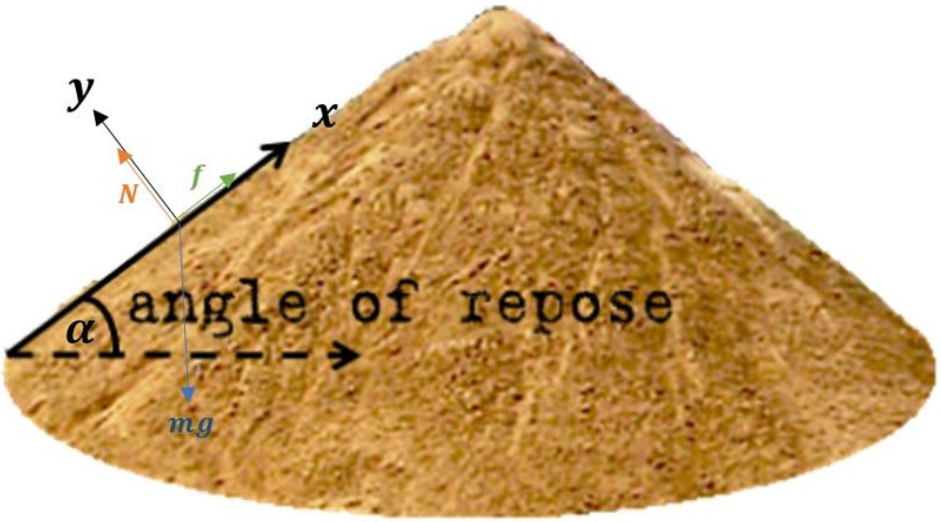


Figure 2. The angle of repose on a sand castle is the steepest angle the sand will remain at before collapsing.

Objective

Design an investigation to determine the angle of repose for a range of different materials.

Equipment

Write a list of the equipment you will need for your investigation.

Hypothesis

Which material do you think will have the highest angle of repose? Explain your answer.

Method

Create a step-by-step method to carry out the investigation. Ensure there are diagrams, showing how you will measure the angle of repose. Show this to your teacher and gain approval before conducting the investigation.

Results and Analysis

1. Create a table of results
2. Convert your results to a bar graph.
3. Order your materials from lowest to highest angle of repose.
4. Which material allowed you to create the steepest slopes (had the highest angle of repose)?
5. Which material had the lowest angle of repose?
6. Which material would be most likely to slip (be part of a landslide)? Explain your answer.
7. Look at the shape of the grains of each material (under a microscope if possible). Considering any features you observe explain why you think the angles of repose for each material were so different.

Evaluation

1. Was this a fair test?
2. What could you do to improve this test?

Discussion

Other than for building sand castles, why is the angle of repose important and who might need to know about it as part of their job?

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

Design an investigation to determine the impact of water on slope stability.

Equipment

Write a list of the equipment you will need to conduct the investigation.

Hypothesis

What do you think will happen as the sand gets wetter?

Method

Write a step-by-step method, with diagrams to explain how you will carry out the investigation.

Results and Analysis

1. Create a table of results
2. Graph your results.
3. Compare your results to other groups, do they follow a similar trend?
4. What effect does adding water have on the angle at which sand starts to slide?
5. What does this investigation suggest about what will happen to slope stability if there is heavy rain? Use data to back up your answer.

Evaluation

1. Was this experiment a fair test?
2. How could you change the experiment to make it better?

Discussion

What could be done on a hillside to try and reduce landslides after heavy rain?

Plant Power

Objective

Design an investigation to determine what impact having vegetation (plant) cover has on the chance of a landslide occurring after heavy rains.

Equipment

Write a list of equipment you will need to conduct the investigation

Method

Write a step-by-step method with diagrams to explain how to conduct your investigation. Show this to your teacher and gain approval before starting.

Results

1. What did you find out during your investigation?
2. Were your results similar to others in the class?

Extension

Deforestation and forest fires can make landslides more likely to occur. Do you agree with this statement? (Use evidence from your investigation to back up your answer).

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 3. 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.

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 including, terracing/benching, drainage, retaining walls, rock bolts and revegetation.

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 4. 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.
4. With the aide of a diagram, explain a situation where a retaining wall would be used.