SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Natural Disasters - Earthquakes	Grade 9 Physical Geography and Physical Processes in Canada

Natural Disasters - Earthquakes

Learning Outcomes

Students will understand that geological features such as fault lines and moving tectonic plates are one of the primary causes for earthquakes.

Students will become familiar with various terms used to describe and measure earthquakes.

Students will have the opportunity to build a shake table and design structures that could withstand the effects of ground forces from earthquakes.

Ontario Curriculum website

Specific Expectations

B1. Characteristics of Canada's Natural Environment and the Impact of Physical Processes
describe various characteristics of the natural environment and the spatial distribution of physical features in Canada, and analyze the role of physical processes, phenomena, and events in shaping them

B2. Interactions between the Natural Environment and Human Activities
analyze interrelationships between physical processes, phenomena, and events and the ways in which various communities in Canada respond to and interact with them

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Description

Students will have the opportunity to learn about earthquakes. They will understand how they are formed, the tools that measure their intensity, and how scientists can predict the potential intensity and location of a future earthquake. An engaging activity will allow students to build a "shake table" to simulate ground shaking from an earthquake and test structures that they will design and build.

Materials

- Kapla blocks / Lego / Knex
- Metric ruler
- Three-ring binder (an old one that can be taken apart)
  *Can also use a piece of wood or cardboard
- Scissors
- Four small rubber balls (each the same size, about 2.5 centimeters in diameter)
- Two rubber bands (each about eight centimeters or longer when flattened and doubled on itself)

- Base plate for testing towers
- Cell phone with "The Arduino Science Journal" app (free)

Introduction

Most earthquakes are caused by the movement of tectonic plates. Tectonic plates are large, broken pieces in the earth's outer crust. These plates move continuously but very slowly, roughly a few centimeters per year. Earthquakes typically occur and they either move apart, slide past each other or push against one another.

The terms used to describe the movement of tectonic plates are:

- Divergent: the plates move apart
- Convergent: the plates push against one another
- Transform: the plates slide past each other

Plates will usually interact at fault lines which are long cracks in the surface of the earth. When they interact, stress and pressure build up which then causes the rock to crack and shift releasing a lot of stored up energy. This burst of energy releases mechanical waves called seismic waves that ripple through the ground causing what we feel as an earthquake.

The focus is the area underground where the rock breaks and the epicenter is the spot on the ground directly above the focus.

After the earthquake, aftershocks may be felt and could cause further damage. This is caused by the rock continuing to adjust itself.

The Richter scale is the tool for measuring the amount of energy that is released during an earthquake. It is a scale ranging from 1 to 10 where the increase of one whole number is 10x the magnitude. For example, an earthquake that measures 7.0 is 100 times stronger than one that measures 5.0.

Scientists can detect the magnitude of earthquakes using a seismograph which measures the vibrations in the ground. These vibrations are called seismic waves.

A seismograph has a heavy weight inside which remains still when there is no movement in the ground. Attached to the weight is a pen which marks the motion relative to the ground. A sensor is firmly attached to the ground and when there are vibrations, the seismic waves will be recorded. They are recorded on a drum of paper or digitally recorded. The result is a seismogram which is a series of wavy lines that can help scientists record the location, intensity and duration of the earthquake. The height of the largest waves is the measurement of the size of the earthquake. Three seismographs are required to locate the focus and several separate seismographs located around the world are required to identify the epicenter.

Nobody can predict when earthquakes will happen, but earthquake scientists use historical data combined with measurements of ongoing plate movement to guess how likely an earthquake will happen in the future. Engineers strive to predict the magnitude of earthquakes to warn people of potential danger.

Structures are designed and built to protect people from the devastating effects of earthquakes. The primary goal of earthquake engineers is to design building that can withstand the forces of earthquakes preventing damage, collapse and saving lives.

Action

Architects and engineers must design buildings that withstand forces such as gravity, the weight of building materials, varying weather and in some cases, larger forces like those that are produced from earthquakes. Stable designs will not cause the structures to weaken or collapse.

The forces that occur in a direction parallel to the ground is known as lateral shaking. This can cause the most damage to a building during an earthquake and must be factored into the design. This does not only protect the structure during an earthquake but also from environmental forces such as wind.

Engineers can test how well a building will hold up to lateral force by placing a model of it on a "shake table" which moves horizontally to simulate the forces experienced during an earthquake.

For the following activity, students are tasked with planning and building well designed structures that can withstand the trembling of their own constructed shake tables.

Procedure

Step 1:
Constructing the "Shake Table"

- Carefully cut the front and back covers off a three-ring binder with scissors. Alternatively, 2 pieces of strong cardboard or 2 pieces of wood of the same size can be used.

- Place the two binder covers on top of one another and attach them together using rubber bands. This is done by stretching a rubber band around each end, about 2.5 centimeters from the edge of the boards.
- Insert the rubber balls between the covers at each corner, placing them about five centimeters in from the edges.

Step 2:
Creating and Testing the Structures

- Attach a large, flat LEGO plate to the top of the shake table by slipping the plate underneath the rubber bands. This acts as your attachment site for your structures.
- Practice creating a lateral shaking movements with the shake table by pulling its top layer horizontally out of alignment and then letting it go.
- Gently try pulling the top layer as far out of alignment as you feel comfortable with (and without damaging the shake table) then measure the distance of displacement, which is the horizontal distance between the top and bottom layers. This measurement of distance will be used for testing your structures.
- Build a variety of towers of increasing height on a nearby surface. Use the same base size and shape for each tower, only changing the heights.
- One at a time, starting with the shortest tower and progressing to the taller ones, secure each tower on the LEGO plate directly in the center of the shake table.
- To test each structure, create a lateral shaking movement using the same distance of displacement you previously measured.
- Students can use their phones to record how much shaking occurs using the "The Arduino Science Journal" app that can be downloaded for free.

Consolidation/Extension

Have students note the following:

- Did all, none or some of the structures fall?
- If some fell and others did not, what were the differences in height between these structures?
- In general, did the taller structures fall more frequently than the shorter ones?

Next steps:
Build structures that are taller with smaller base sizes and experiment using different materials when constructing your structures.
Marshmallows, spaghetti, toothpicks, straws are all alternative materials that can be used.

Extension:
Build a simple seismometer
https://www.sciencebuddies.org/stem-activities/make-a-seismograph

Additional Resources
Earthquakes Canada
Government of Canada Bilingual site:
https://www.earthquakescanada.nrcan.gc.ca/index-en.php

Canadian Red Cross
Bilingual site:
https://www.redcross.ca/how-we-help/emergencies-and-disasters-in-canada/types-of-emergencies/earthquakes/earthquakes-information-facts