Building Strong Mines

Lesson Plan

Description

Students will learn about the roles involved in mine construction and will build their own mines, learning about structures and forces along the way.

Learning Outcomes

- Associate careers with the design and use of mining infrastructure
- Understand how forces act on structures, and how structures respond to those forces
- Apply knowledge of forces and structure design to make a structure which withstands a force

Introduction

Forces

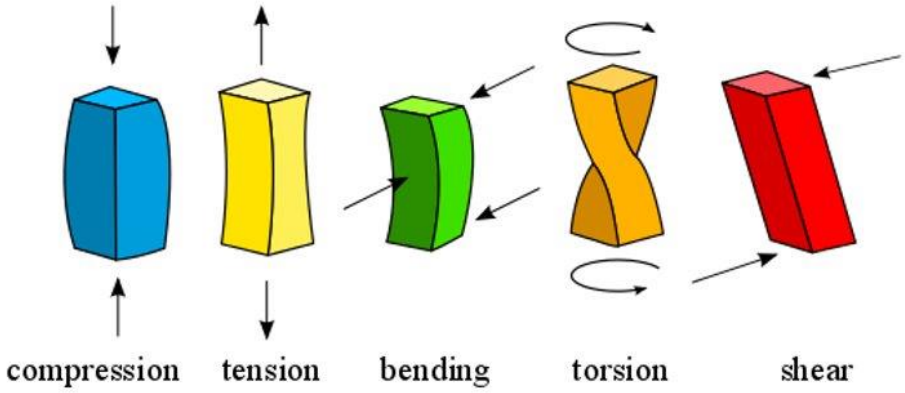
Compression: occurs when an external force presses inward on an object causing it to become compacted.

Tension: occurs in a rope, string or wire when pulled on by external forces acting from opposite sides.

Bending: occurs when an external force is applied to the structure causing it to experience compression and tension forces.

Torsion: occurs when a load is applied through torque, which can cause a material to twist.

Shear: the result of two external forces acting in opposite directions, typically with the force being applied perpendicular to the surface.



Building Toolkit

The following structures can help a building to withstand different forces.

Columns: Columns are structural elements that are designed to support a structure by distributing the force from above. A square or triangular column is less strong than a round column because the corners are fail points. A failure point is where the structure first fails, causing the entire thing to be compromised. These failure points occur around the corners and into one of the sides. A circular column can handle more force, but when it does fail, it will crumple completely. There is no single failure point, rather the entire column will fail. That's because a circular column has no obvious sides or corners, and so no obvious weak points. It is able to evenly distribute the force around the entire column, and only fails when the force is too much for the entire column rather than a single point.

Trusses: A truss is the name for the shapes a structure is made up of – for example, the triangles you see in bridges. Triangles are the best shape to make a truss from. A square truss has one degree of freedom meaning that it can move in one direction, a rotational direction, which makes it weak to shear force. A triangular truss however has zero degrees of freedom, meaning that it cannot rotate. Forms that can't rotate don't deform (or fail as easily). Tipis have their poles arranged in triangle shapes, for example, and plank houses use triangular trusses in the roofs.


Materials: The material you use can also make a big difference in how the structure will withstand force. If your material bends too much, the whole thing can be unstable. If it is too brittle, it will shatter under too much of almost any force. Your material needs to be strong enough to withstand force, and flexible enough to absorb some shock without bending so much that the structure fails. The exact needs may change depending on the kinds of force the structure will have to go through. What to build a structure from should be considered from the first part of the design phase. Different Indigenous groups use different materials for their buildings – in BC, plank houses are built with sturdy logs and planks of wood. In the prairies, Tipis use fairly sturdy wooden structures with fabric over them. In Ontario, wigwams and sweat lodges are of supplier, bendable branches, covered with fabric or other materials.


Load Distribution: In a tall building especially, load distribution is all about where the structure is heavy, and where it is light. A heavy load should always go near the bottom of a structure. A top-heavy structure will topple more easily because the centre of gravity is higher. A low centre of gravity contributes to stability in a structure. This is often accomplished with a wide base, and a structure which gets narrower closer to the top. The Tipis of the Blackfeet Nation are built with a wide base and a narrow top, for example.

Arches: Many Indigenous peoples use arches in their architecture, from the Anishinaabe wigwams and sweat lodges to the Inuit igloos. Arches convert tensile force into compression force, with the ground pushing up at the arch, and whatever is above the arch pushing down. Arches in combination can form a dome.

Mine Construction

There are two main types of mines: open pit, and underground. The forces that act on these types of mines are different.

Underground mines must be designed to withstand compression force, but also bending and shear force from the tremors caused by the explosives used to create new drifts. The drifts themselves can't be too close together – a structure which is too hollow will cave in. Supporting structures need to provide compression and tension forces which help stabilize the mine. Screening and bolting can help with this. Bolts can be inserted into the rock like hairpins, keeping everything in place.

Open pit mines also need to withstand bending and shear force from tremors and explosives. The load distribution in an open pit mine is vital, as is the grading – the mine needs to be shaped just right,

using angles and grades to make sure that equipment can travel in it, and the sides won't fall in. They need to use tension and compression forces to hold things in place.

Careers in Mine Construction

Building a mine is a team effort. To build a mine, we need:

- Equipment operators
- Labourers
- Construction helpers and miners
- Engineers
- Technicians
- Superintendents and Supervisors
- Trainers

And more! There are a lot of people involved, from making the plans to doing the actual building.

Action

In this activity, we will complete timed challenge stations to model how mines stand up to forces.

Put the class into groups of 2-4. Each group will receive a challenge log which they will use to plan each challenge, and to record their results and observations.

Set out the materials and instruction card for each station. Make sure there is adequate room for the students to work. The stations can be completed in any order, but each group must complete every station. Give students 13 minutes at each station, and 2 minutes to switch.

Station One

Challenge: Build a mine drift which holds up to compression. A mine drift is a horizontal tunnel. Build around your drift to give it support, while making sure that a toy vehicle can still travel through it.

<u>Materials:</u>

- Toilet paper and/or paper towel tubes
- Toothpicks
- Popsicle sticks
- Straws (paper or plastic)
- Tape and/or glue
- Weights (textbooks work just as well)
- Toy car

Instructions:
The toilet paper and/or paper towel tubes represent your drift. Lay it vertically on a surface. You must reinforce the structure so that it can hold weights on top without any fail points.

Station Two
Challenge: Build an open pit mine that can be driven down safely. You have been provided with a cardboard box. A vehicle must get from the top to the bottom without falling. It must start at the very top, and reach the very bottom, which must still be visible. Use the materials provided to make a track for the vehicle.

Materials:
- Foam/Styrofoam
- Cardboard
- Cardboard Box
- Elastics
- Scissors
- Toothpicks/Popsicle Sticks
- Tape/Glue
- Toy car

Instructions:
Use the materials provided to create a track which the vehicle can use to traverse the mine.

Place the toy at the top of the track when you are finished and see if it can make it to the bottom.

When you are successful, it is time for a final stress test. Explosives are used to expose more ore. Shake the desk your mine is on. If any part of your track collapses, re-evaluate how it is secured and try again. Make sure it remains driveable.

Station Three
Challenge: Some above-ground structures on a mine site, above or below ground, are very tall. Build a structure which is minimum 50cm tall, which can remain stable when exposed to wind.

Materials:
- Cardboard
- Paper
- Tape/Glue

- Scissors
- Weights
- Popsicle Sticks
- Blow Drier

Instructions:
Use the materials provided to build a structure. It must be minimum 50cm tall and use as few materials as possible. Consider your centre of gravity and load distribution.

When your building is complete, blow air at it using a blow drier for 30 seconds. If it falls over, make some changes and try again.

Station Four
Challenge: Cranes need to stand up to tension and compression forces, when they're lifting a weight. Build a crane that uses trusses to withstand a variety of forces while remaining mobile.

Materials:
- Popsicle Sticks
- Tape/Glue
- String, Twine, or Rope
- Elastics
- Weights

Instructions:
Use the materials provided to build a crane which can lift the load at this station. It should be able to move up and down, and to rotate around its base, all while the load is attached.

Station Five
Challenge: Place bolts to make sure the rock is held in place using the fewest number of bolts possible.

Materials:
- Paper towel tube with holes punctured in it
- Dowels
- Marbles or Pebbles

Instructions:
Stand the paper towel tube on its end. Each dowel should go in one hole and out another somewhere on the tube. Place as few dowels in the tube as you think will hold the marbles,

and then drop the marbles in the top of the tube. If any fall out, try again, changing the angles and/or adding dowels as needed until no marbles fall through.

Gameplay

Students will play the Mine Evolution digital game and see mining in action while competing to mine the most ore. Scores for each student can be collected on the scoresheet.

Materials:

- 1 device for each student

Instructions:

- Each student will need a device (laptop, tablet, or mobile phone).
- Each student will need to go to www.mineevolution.ca on their device. Click "Get the Game". Students can download either the Google Play (Android devices and Chromebooks), App Store (Apple devices), or PC versions of the game depending on what type of device they are using.
- Once the game is downloaded, select "Challenges".
- Select "Mine Race" and begin playing! The tutorial will show students how to play. There is also a tutorial video and a "How to Play" document with tips and tricks on the Science North educator resources website (https://schools.sciencenorth.ca/educator-resources).

Consolidation/Extension

At each station, what forces are at play? What structures were used at each station that helped mitigate those forces?

Mine Engineers are responsible for the design of a mine. They must make sure the mine is safe, and they must minimize the environmental impact. What education is required to be a mine engineer? What are their daily responsibilities? What is their typical salary?

Accommodations/Modifications	Assessment
Use materials which are available to you for these activities. When students are working in groups, make sure there is a role for each person.	Have students made thoughtful and accurate observations at their stations? Do students make adjustments and changes to their structures? Do students make connections between structures, mining, and careers?

Additional Resources

https://www.miningneedsyou.ca/world-of-mining/
https://www.miningneedsyou.ca/interactive-quiz/

https://www.sciencenorth.ca/teachers -> look for the physics lessons for your grade!
https://schools.sciencenorth.ca/educator-resources -> look for the physics lessons for your grade!

https://miningmatters.ca/resources/education/mining-week