Bridge Builders Overview

From ancient empires to modern times, bridges have shaped communities and built civilizations. The importance of bridges in history and understanding how engineers utilize physical science concepts when building a bridge are compelling reasons to study bridges.

Bridge Builders focuses on the three most important bridge styles - beam, arch, and suspension. The essential components of each style are demonstrated using the bridges at Capilano Suspension Bridge Park as real and functioning examples. The advantages and disadvantages of each style of bridge are demonstrated. Students participate in activities - some as a class, some in small groups.

Of primary interest is Capilano Suspension Bridge itself – the famous hanging bridge built originally of rope and cedar planks. Students will also study Treetops Adventures, which includes a series of seven smaller suspension bridges, and discuss the similarities and differences of these two different styles of suspension bridge. In Capilano's outdoor classroom, a suspension bridge in the style of Lions Gate Bridge will be constructed using student volunteers. With several examples of small beam bridges in the park, and with the help of a few simple demonstrations, students will delve more deeply into this type of bridge. As well, with simple demonstrations and small group work students will learn about the arch bridge.

The Bridge Builders program offers a balance between work in the outdoor classroom and a purposeful tour of the park.

"Bridge Builders"
Background

Why are bridges built?

Simply put, to get to the other side. In most cases, bridges through the ages have been built to provide a shorter route. Geographic obstacles such as rivers, streams, creeks, lakes, and bits of the ocean like bays and inlets often interfere with a direct route. Bridges are built to avoid the long or impossible route around such obstacles. Islands may be reached by boat but bridges often provide a cheaper and more convenient connection. Some geographical features are not water related, such as dry gorges and canyons and they too may be crossed by building bridges. In addition to the many geographical or natural obstacles, there are man made obstacles. Quite often for ease and safety bridges are built to avoid intersections of roads. Cars, trucks, buses, trains, bicycles, and pedestrians are frequently made to cross paths and that can be a dangerous situation. Overpasses and pedestrian walkways are frequently used to make a safer and more convenient situation. Building bridges is always a challenge. It's safe to say that bridges are a part of our daily lives.

How are bridges classified?

Well, in several different ways. Bridges may be classified according to the traffic. For example pedestrian bridges, train bridges, and the usual motor vehicle bridges. Bridges can also be classified according to the main structural material. For example wooden bridges, concrete (including reinforced concrete) bridges, steel bridges, aluminum bridges, rope and cable bridges, and stone bridges. In our Bridge Builder program we focus on classifying bridges according to the type of structural support used. Since the beginning of time, bridge builders have built three major types of bridges: the arch bridge, the beam bridge, and of course… the suspension bridge!

Bridge Builders - The Big Three.

<u>Arch Bridge</u>

The arch bridge consists of semicircular arch structures (almost like half moons) with abutments on each end. The goal of the arches is to send the weight of the bridge and its load to the abutments. In other words, the arches push the weight of the bridge and its load to the two extremities of the bridge. The technology of building arches for bridges and other structures has evolved from mostly semicircles in the early forms to circle segments that are less than half a circle and later on to other mathematical curves such as oval segments. While the curve of arches adds great beauty to structures, sometimes the curves present practical problems such as making a level bridge deck (or road bed).

The main components of an arch bridge are the arch and abutments at each end of the arch. The arch may serve as the bridge deck or the deck may be added to achieve a less curved surface.

<u>Beam Bridge</u>

The beam bridge consists of a horizontal beam structure supported by piers. The weight of the beam pushes straight down onto the piers. This method is great for short span bridges. The beam bridge is very practical in that a bridge deck can be placed directly on the supporting beams to achieve a flat and level surface for the bridge traffic.

The main components of a beam bridge are the beams and supports at each end of the beams. The road bed is usually applied directly to the beams.

Suspension Bridge

The bridge at Capilano is what we call a simple suspension bridge. A suspension bridge can span thousands of feet, much more than any other type of bridge! It is the best kind of bridge to build to span a large body of water. A suspension bridge is a bridge where cables are strung across from one point to another (for example, one side of a canyon to the other). A deck is then attached to the main suspension cables or as in the case of most suspension bridges the bridge deck is suspended from the main cables using suspenders.

The main components are the main suspension cables, anchors, and bridge deck. Most suspension bridges also have suspenders, which connect the main cables to the bridge deck. The majority of suspension bridges have two towers.

These are the three key structural types of bridges (there are other less common types), which are the core of the Bridge Builder program.

Truss

Trusses are often used to strengthen any bridge type. Trusses are made up of a series of triangles created by connecting straight steel bars, wood, or other structural material. These structures are extremely rigid and can hold up against weight and vibration. Some use truss as a modifier; truss beam bridge, truss arch bridge, etc. Some consider truss as a separate bridge type.

Cable stay bridges are very popular today. Some consider this as a separate category while others group the cable stay bridges as another version of a suspension bridge.

Forces and Materials

As with any structure there are forces to consider and matching those forces with appropriate materials and design.

There are two main forces that are a focus for Bridge Builders. Pull and push are the common words for tension and compression. Cables and ropes are often used to withstand a pulling force. Rigid materials such as concrete, steel beams, stone, and wood timbers are often used to withstand a pushing force.

"Bridge Builders"

Suggestions for in class activities:

These activities may be designed for single student, student groups, or entire class projects. Gathering magazines, newspapers, and electronic sources for pictures and articles about bridges nearby and/or worldwide will enhance many activities.

Social and personal impact.

In class activities may focus on the social impact of bridges. Bridges are usually built to ease a need within a community. However with each structure we build there are costs; financial, ecological, and aesthetic.

An appreciation of the importance and abundance of bridges is connected to the geographical locations that communities choose to settle and develop. Water and people are necessarily tightly linked. Delve into the many ways that water is important to people. What bodies of water are close by? Do the same for essentially any city in the world.

List bridges that you cross going to school, shopping, visiting friends or relatives, or on vacation.

Use a map of the lower mainland and use pins to show the location of bridges. Add information such as name of bridge, bridge type, traffic type e.g. pedestrian, car, train, etc. Name communities connected by a bridge.

What problems did the bridge solve for the community?

When was it built?

What are the main building materials?

Do you think the bridge is ugly, beautiful, impressive, or hardly noticed?

Science, Mathematics, and Engineering.

Bridges as structures have connections with mathematics, science, and applied sciences. Forces such as pulls, pushes, twisting, compression, tension, and gravity are considered when building a structure. Materials such as concrete, steel, wood, rope, stone, etc must be matched to purpose in the structure. Shapes common in geometry are integral to designing arches and trusses.

Language Arts

The vocabulary associated with bridges might be blended with portions of the language arts activities such as spelling. Write a short piece that includes a bridge.

Art and Engineering.

Drawing or modeling bridges will help students to think about the detail of bridges.

RESEARCH SUGGESTION:

<u>Famous Bridges</u>

Most children are familiar with the names of at least a few bridges. Some may be local, others may be located across Canada, USA, or even more distant.

An activity might begin with the name of a bridge and then gathering pictures and information about that bridge.

Create a matching game of name, location, and picture of very famous bridges.

RESEARCH SUGGESTION:

Bridge Traffic.

Create a picture collection of bridges that show examples of the wide range of bridges designed for special kinds of traffic.

It is relatively easy to find examples of cars, trucks, and pedestrians; it may not be too difficult to even find examples of buses, motorcycles, bicycles, sky train, freight and passenger trains crossing a bridge. What about various animals, carts, wheelchairs, skateboarders, roller bladers, airplanes, strollers, horseback riders, horse carriage, ox and cart, etc.?

Did you know that there is a bridge for airplanes? Bridges are provided for wild animals to cross over busy highways. Farmers often have bridges for their livestock.

RESEARCH SUGGESTION:

Building Materials

Invite students to provide examples of the various materials used to build bridges. Students may be able to show that popular building materials have changed over the centuries.

RESEARCH SUGGESTION:

Classification

Using a picture collection, have the students group bridges based on their own criteria. Challenge one another with uncovering the method of classification.

EXPERIMENT SUGGESTION:

Push, Pull, and Twist!

Forces are very important to understand when designing and building any structure. A simple demonstration and experience of three forces; tension (pull), compression (push), and torsion (twist) can be done with student pairs. With the usual cautions about this not being a wrestling match, have them grab each other's arms at the wrist and gently pull against one another. This pulling on the arms creates a tension force in the arms. This is tension. Then have the students place their palms together and push against their partner. This is compression.

Finally, have the students grab a hold of each other's wrists and gently rotate their arms. This is torsion.

Have students think about simple activities such as standing, hanging from a bar, push-ups, or turning around to talk to their fiend behind them. Legs and spinal are being compressed; arms and spinal column are being stretched; and spinal column is twisting.

Structural materials are subjected to these forces and have to be designed not to fail just like our bodies are designed not to fail us.

EXPERIMENT SUGGESTION:

A Test of Strength

The strength of various materials varies tremendously. Some materials have surprising strengths and equally surprising weaknesses. Use simple materials like strips of paper, full sheets of paper, length of string, a straw, flat cardboard, corrugated cardboard, bamboo skewers, elastic bands, spaghetti, etc. Have students devise a way to test the tension (pull) strength of various materials. Just hanging on to each end with fingers and pulling is the simplest approach. Using some type of clip to grab onto each end may enable the students to measure the weight (pull) needed to cause a material to fail (break). Test how well a material withstands a compressive force. Grab each end and push. Try twisting materials. It

may be an interesting conversation to discuss that some materials do not resist a force very well however they do not break.

EXPERIMENT SUGGESTION:

Shape Matters

Pieces of paper, flat cardboard, and corrugated cardboard help investigate how the shapes of materials affect strength. Use some blocks or books to make a couple of piers. Bridge the gap with paper. A flat sheet is not very effective. Introduce a flat sheet of cardboard. Bridge the gap with the cardboard. Is it better than the paper? Discuss why. Introduce the corrugated cardboard. Which is the best (strongest) material? Introduce the idea that folding and rolling paper (changing its shape) can greatly increase its strength. The compressive strength of paper can be greatly increased with careful folding or rolling. Have the students explore different ways to fold or combine paper in order to make it stronger (accordion style, rolled-up, layered, etc). They can then test their various methods with standardized weights and see which method holds up best.

Below are suggestions of good websites and keywords that you may find useful for web research and background information or for any pre or post classroom activities you may wish to conduct.

Go to Wikipedia home page.
http://en.wikipedia.org/wiki/Main_Page

In the search box type in:

Bridge - This entry is a good general description of several types of bridges
Foot Bridge - Entry focuses on pedestrian bridges
Suspension Bridge
Beam Bridge
Arch Bridge
Tied-Arch Bridge - Entry gives information about trusses; some classifications of bridges identify a truss as a bridge type, other classifications identify a truss as a modifier for Beam, arch, and suspension bridges
Capilano Suspension Bridge Park
List of Crossings of the Fraser River

Or type in the name of specific bridges such as:
Granville Street Bridge, Oak Street Bridge, Golden Ears Bridge or Lions Gate Bridge
List of Bridges in Canada - this entry lists bridges by province
List of Bridges - this entry lists bridges by country

Google entries
http://www.google.ca

In the search box type in

How Bridges Work – A variety of excellent websites are featured which contain good sources of information.
Top 10 Structurally Amazing Bridges

Please copy and paste the following link for photos taken of our bridges and structures at Capilano Suspension Bridge Park
http://www.flickr.com/photos/capilanosuspensionbridge/sets/72157628084003226/