Suspension Bridge Model WIP

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Meta Description

Build a simple suspension bridge model. Understand the forces acting on a bridge and its special structural elements. A fun activity for young engineers.

Learning Objectives

Introduction to the principal forces acting on a bridge.

Introduction to the different structural elements of a suspension bridge.

Practical understanding of the importance of different parts of the structure.

Key Terms

Anchorage
Bridge anchorages consist of huge concrete blocks or solid rock to which a suspension bridge is rooted. They channel tensional forces in the cables down into the ground.

Compression Force
A force which causes an object to be squashed or squeezed.

Deck
The part of the bridge commuters use. It can consist of a roadway, railway or pedestrian path.

Supporting cables
Metal ropes, usually made of steel, used for suspension in bridges. They channel tensional forces in the bridge to the anchorage.

Tension Force
A force which passes through a cable when it is pulled from opposite ends.

Tower
Supporting pillars in a bridge, usually made of metal or reinforced concrete. They channel compressive forces in the bridge into the earth.

Method

Step 1
Cover the work surface with newspapers.

Step 2
The base of the model represents the river, valley or road the bridge passes over and the banks on either side of the bridge. Decide which scene your bridge will pass over and colour it in accordingly. Set aside.

Step 3
From the corrugated cardboard cut out four 15cm x 7cm strips. These will be the towers. Colour in with any colour.

Step 4
Roll up the corrugated cardboard strips lengthwise. Secure with tape. Ensure the towers are all of the same thickness.

Step 5
Glue the towers to the base. Ensure that together they form a rectangle of about 20cm x 7cm. Let the glue dry.

Step 6
Measure the required width of the deck. Cut out a strip of corrugated cardboard with that same width and a length of about 30cm. The deck can be decorated as road, railway or footpath.

Step 7
The cabling can now be set up. Cut two pieces of string about double the length of the bridge.

Step 8
At the top of each tower, on either side, cut holes to pass the string through. The holes should be parallel to the deck.

Step 9
Pass a piece of string from one side to the other of one of the towers. Drape the string across from tower to tower, parallel to the deck. Ensure the strings form an arc. Tape the ends of the string at either end of the bridge to the base. These joints represent the bridge anchorages.

Step 10
Suspend the deck of the bridge between the two towers. To do this, tie a piece of string to the cable arc, pass it under the bridge, and then fasten the other end of the string to the opposite arc. Repeat this process along the length of the bridge.

Step 11
Bend the ends of the deck and tape them to the base of the model, to form the ramps leading onto and off of the bridge.

Alternative Method

- Chenille stems (pipe cleaners) can be used to make the cabling, instead of the string.

Precautions

1. Cover the work surface with newspaper to protect from glue and colours.
2. Reuse and recycle when possible!
3. Use scissors with caution. When not in use, leave them resting on a table. Carry with the point facing downwards.

Narrative

You already know a lot about how bridges work. Bridges are great at balancing forces you already know all about.

Have you ever played in a tug of war? In the game, the teams on both sides pull the rope as hard as they can. The rope ends up pulled taught by the forces produced by the teams. Forces which pull on a material are called tension forces. The cables in a bridge take the tension forces of the structure and send them to anchors at either end of the bridge. The anchors hold onto the cables, keeping the bridge stable.

Have you ever squashed a bottle? The force you exert when you squeeze or squash something is called a compression force. The heavy things passing along a bridge create a downward force which compresses the towers.

Questions

Why do the towers in a bridge remain upright?
The towers are driven deep into the ground.

How much weight can a bridge take?
Different for each bridge. Engineers use standard equations to determine the maximum load.

Why does the bridge deck not collapse?
The bridge deck is reinforced and forces are distributed throughout the structure.

What do the cables do?
Transfer forces to the towers and anchorages.

What is the bridge made of?
Cables: Usually steel Towers: Steel and possibly reinforced concrete.

Brief Explanation

Suspension bridges are used throughout the world to cross bodies of water, valleys and roads. Famous suspension bridges include the Golden Gate Bridge and Clifton Suspension Bridge. A suspension bridge's structure is made up of distinct parts: the deck, towers, cables and anchorage.

When loads such as people, cars and trains pass along the deck, their weights exert a downward force called a compression force. The cables transmit this force into the towers. The towers direct the forces into the ground.

Loads on the bridge also create tension in the cables. This force is transmitted along the cables which are anchored deep into the ground at either end of the bridge. Thus, the tensional forces dissipate into the earth.

Engineers use standard equations to design bridges. Important factors to consider in the design are the length of the bridge, the loads it will carry, the weather conditions and geography of the surrounding area.

Detailed Explanation

There are two principal types of suspension bridges: cable-stayed structures and modern suspension bridges. The compression and tension forces are similar in both types of bridge. Cable-stayed bridges have an A-shaped cabling configuration. All forces are channelled into the towers, so there is no need for an anchorage system. Cable-stayed bridges span shorter distances than modern suspension bridges.

Modern suspension bridges exhibit an M-shaped cabling configuration. In this structure, cables are passed over towers and anchored on both ends. The towers provide the necessary support to extend the bridges over long distances. Thinner cabling is used to suspend the deck.

The majority of forces in the bridge are transferred to the anchorage system. Within this system, the cables are spaced out over a large area. This ensures that the load is evenly distributed, thus preventing the cables from breaking free. The cabling system can withstand substantial tension but is weak under compression. The compressional forces on the deck are thus converted to tension in the cables, which then compress the towers.

The construction of a suspension bridge involves wide-ranging design considerations. These include the type of foundation used, the mix of concrete and the time it takes to develop strength, the support systems required during construction, elevation of the deck and choice of cable.

Applications and Research

Applications

Bridges are used worldwide to cross over valleys, roads, rivers or other bodies of water. Different bridges are designed to sustain different forces. Rope and plank bridges, made of wood, can usually only take the weight of a few humans. Although arch bridges, usually constructed from stone, can bear more weight, they can only have a limited length. Beam bridges and suspension bridges are widely used in transport infrastructure. Bridges with triangular structures such as truss bridges are very sturdy and are often used in rail lines. Bridges used in transportation carry heavy loads and must rely on strong metals such as iron or steel and concrete supports.

Research

Some current research is focused on improving systems for bridge management. These systems are used to evaluate the safety of bridges. For example, researchers are investigating new ways to calculate the integrity of concrete and simulate its degradation. They are also trying to model degradation is a bridge's ability to carry loads. Researchers are also developing principles to make decisions on bridge maintenance, repair and replacement.

Investigation

Instead of using corrugated cardboard for the deck, paper or cereal box cardboard could be used. A small toy car could be run across each surface, and the effect of the loading on the deck investigated. Try out combinations of different loads on different materials.

Subjects

Engineering & Technology
Physics

Education

Primary

Time Required

~1 hour
Preparation: 10 minutes
Conducting: 40 minutes
Clean Up: 10 minutes

Cost

0 – 10 €

Recommended Age

3 – 6
6 – 9

Number of People

1 participant

Supervision

Required

Location

Indoors
Outdoors
Festivals
Laboratory

Materials

Cardboard base(approx. 40cm x 15cm)

Colouring utensils (crayons, paint, pencils etc)

Corrugated cardboard

Glue

Paper puncher

Ruler

Scissors

String or baker’s twine

Tape

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Sources

Engineering 201: DIY Recycled Suspension Bridge

The Suspension Bridge

Feel the Forces of a Suspension Bridge

Hands-on Activity: Bridge Types: Tensile & Compressive Forces

Suspension Bridges – Design Technolgy

Constructability Considerations in Long Span Bridge Design

Suspension Bridge Activity

Additional Content

Education activities for kids: spaghetti bridges (Beginner)

24 of the world's most amazing bridges (Beginner)

25 of the most impressive bridges (Intermediate)

Take it to the bridge: the Tehran architect striking the right chord in Iran and beyond (Intermediate)

Why are there so many different types of bridges? (Intermediate)

Bridge designing (Advanced)

The future of bridges (Advanced)

The new technology of bridge design (Advanced)

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