

## SUGGESTED REFERENCES

- *Official website of the Millau Viaduct in France (the largest bridge in the world)*  
[www.leviaducdemillau.com/english/index.html](http://www.leviaducdemillau.com/english/index.html)
- *Explaining why the Millenium Bride in London wobbled*  
[www.sciencedaily.com/releases/2005/11/051103080801.htm](http://www.sciencedaily.com/releases/2005/11/051103080801.htm)
- *The Gateshead Millenium Bridge homepage*  
[www.gateshead.gov.uk/Leisure%20and%20Culture/attractions/bridge/Home.aspx](http://www.gateshead.gov.uk/Leisure%20and%20Culture/attractions/bridge/Home.aspx)
- *Cable-Stayed Bridge - How bridges work*  
<http://science.howstuffworks.com/engineering/civil/bridge7.htm>
- *Skye Bridge – Undiscovered Scotland*  
[www.undiscoveredscotland.co.uk/skye/bridge/index.html](http://www.undiscoveredscotland.co.uk/skye/bridge/index.html)

## NATIONAL SCIENCE EDUCATION STANDARDS

### Grades 9 - 12

#### Science & Technology

Abilities of technological design

Understandings about science & technology

### Grades 9 - 12

#### Science in Personal & Social Perspectives

Populations, resources, & environments

Science & technology in society

\*Source: *National Science Education Standards, 1996, National Academy Press*

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# Science Screen Report

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## ENGINEERING - *Bridges by Design*

## SYNOPSIS

Engineers and architects are creating bridges that combine the best of both art and design. Bridges are no longer just a tool to get from one side of the river to the other. Some bridges, such as the Gateshead Millenium Bridge in England, have the goal of being aesthetically pleasing and efficient for pedestrians. Others such as the Skye Bridge in Scotland rely on the cantilever design to span a distance equivalent to three and a half jumbo jets.

Bridges are often classified by their structure and how the forces of tension, compression, bending, torsion and shear are distributed. In this edition, students will learn how designs vary depending on the function of the bridge, the environmental factors, the materials, and technology used to construct them.



## CURRICULUM UNITS

- ARCHITECTURE
- ENGINEERING
- ENVIRONMENTAL SCIENCE
- PHYSICAL SCIENCE
- PHYSICS

## RUNNING TIME

17 minutes

electric sky

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## BACKGROUND

There are six main types of bridges: beam, cantilever, arch, suspension, cable-stayed and truss. Bridges are used for several different purposes; some are only for pedestrians while others are used exclusively by automobiles. Bridges are built to cross rivers and lakes or to make deep ravines easier to cross.

The Gateshead Millennium Bridge in England is the first tilting bridge in the world. It is strictly for pedestrians and cyclists, and was built to span the river Tyne connecting Newcastle to Gateshead. Its unique tilting feature was included to allow boat traffic to pass underneath. Six 45 cm (18 in) diameter Hydraulic rams, three on each side, each powered by a 55 kW electric motor rotate the bridge on large bearings to allow watercraft to pass underneath. It takes as little as 4 minutes to rotate through the full 40° from closed to open, depending on wind speed. As it tilts open, the center of mass moves across the pivot point, requiring very little power from the rams as they simply hold the bridge open.

The Skye Bridge in Scotland has an arched girder that pushes the free cantilever method with its 250 meter span. It connects the mainland of Scotland with the isle of Skye, which had relied on ferries for centuries. There are only two methods available for a span of 250 meters, a box girdered balance cantilever design or a cable stayed. The cantilever design was much more economical for the small town on the island, and the residents felt it was better in terms of its visual appearance and its impact on the environment.

London's Millennium Bridge is a steel suspension bridge that crosses the river Thames, built specifically for pedestrians. Eight suspension cables pull with a force of 2,000 tons against the piers on the banks, which can support a working load of 5,000 people at one time. However, the bridge was shut down after its opening day because of an unexpected wobble caused by synchronous lateral excitation. The problem was fixed by engineers and the bridge was later reopened after it was retrofitted with 37 fluid viscous dampers to dissipate energy and 52 tuned mass dampers to control vertical movement.

The Millau Viaduct in France is the tallest bridge in the world and crosses the valley of the river Tarn. Constructing this massive bridge was cheaper than the alternative of tunneling through the hills flanking the river, and shortens the drive by 100 km and up to 4 hours. The Millau Viaduct is the longest cable-stayed bridge in the world. It has a steel deck, rather than the more usual concrete roadbed.

## CRITICAL THINKING EXERCISES

1. How do scientists and engineers decide which type of bridge is the right one to build in a specific place? List the variables scientists might consider when choosing the design for a bridge.
2. Why is it important that the science of bridge engineering be exact? How do scientists cope with unexpected problems, as was the case in the Millenium Bridge project?
3. Create a model for a bridge to be designed in your location. What purpose will the bridge serve? Describe environmental concerns that may hinder your project.

## CAREER POSSIBILITIES

- ARCHITECT
- BUILDING CONSTRUCTION
- ENGINEER

## ADVANCED ORGANIZERS

Prior to viewing this program, students should have some understanding of the following Benchmarks for Science Literacy, Oxford University Press which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

### Benchmark 3. The Nature of Mathematics

#### Section B: Mathematics, Science, and Technology, Grades 9-12

- Mathematics provides a precise language to describe objects and events and the relationships among them. In addition, mathematics provides tools for solving problems, analyzing data, and making logical arguments.
- Developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved.
- The development of computer technology (which itself relies on mathematics) has generated new kinds of problems and methods of work in mathematics.
- Developments in mathematics often stimulate innovations in science and technology.
- Mathematics is useful in business, industry, music, historical scholarship, politics, sports, medicine, agriculture, engineering, and the social and natural sciences.

### Benchmark 3. The Nature of Technology

#### Section A: Technology & Science, Grades 9-12

- Engineers use knowledge of science and technology, together with strategies of design, to solve practical problems. Scientific knowledge provides a means of estimating what the behavior of things will be even before they are made. Moreover, science often suggests new kinds of behavior that had not even been imagined before, and so leads to new technologies.

*\*Benchmarks can be found at [www.project2061.org/tools/benchol/bolintr.htm](http://www.project2061.org/tools/benchol/bolintr.htm)*

## VOCABULARY

- Bearings** . . . . . A support, guide, or locating piece for a rotating or reciprocating mechanical part.
- Box Girder** . . . . . A large beam, as of steel, reinforced concrete, or timber, for supporting masonry or joists, that is hollow and square, or rectangular in shape.
- Cable Stayed** . . . . . A bridge consisting of one or more columns, towers, or pylons with cables supporting the bridge deck.
- Caisson** . . . . . A watertight chamber open at the bottom and containing air under pressure, used to carry out construction work underwater.
- Cantilever** . . . . . Any rigid construction extending horizontally well beyond its vertical support, used as a structural element of a bridge or building foundation.
- Cofferdam** . . . . . A watertight structure, usually of sheet piling, that encloses an area under water, pumped dry to enable construction work to be carried out. Below a certain depth a caisson is required.
- Dampening** . . . . . Shock absorption system that dissipates energy.
- Dredge** . . . . . To remove material from a riverbed or channel by means of a dredge.
- GPS** . . . . . (Global Positioning System) – A system of satellites combined with receivers on the Earth that determine the latitude and longitude of any particular receiver through triangulation.
- Hydraulic** . . . . . Operated by the pressure of water or other liquids. Hydraulic systems, such as hydraulic brakes, allow mechanical force to be transferred along curved paths (through pipes or tubes) that would be difficult for solid mechanisms, such as levers or cables, to negotiate efficiently.
- Parabolic** . . . . . Having the form of a parabola. Parabola: a plane curve formed by the intersection of a right circular cone with a plane parallel to a generator of the cone; the set of points in a plane that are equidistant from a fixed line and a fixed point in the same plane or in a parallel plane.