DIFFERENT TYPES OF BRIDGES

There are several basic bridge types, but because the individual requirements for each bridge are different, there are numerous design variations.

The BEAM BRIDGE

This is the simplest type of bridge, made from a straight section - the beam - that rests on two supports, one at each end of the beam.

Construction and materials:

The beam bridge supports its own weight and its load, on upright, or vertical, piers. This type of bridge is typically used to span narrow distances over small streams or rivers, or over a highway. This is because longer beams tend to bend in the middle and need additional support.

While wood and stone were common materials in the past, modern beam bridges are usually constructed from steel and reinforced concrete.

Forces acting on the bridge:

The forces acting on a beam bridge compress the top, but stretch (place under tension) the bottom of the beam. The piers supporting the weight of the bridge are under compression.

The TRUSS BRIDGE

A truss bridge is a type of beam bridge in which the beam is constructed with a latticework of straight sections, (usually steel,) joined together to form a series of triangles. This allows the beam to become thicker without significantly increasing the weight. A triangle will produce a strong and rigid structure because it prevents a structure from bending, twisting or pulling out of shape.

Constructions and materials

Early truss bridges included few triangles and were made of wood (See Figs. 34 and 35.) As better materials and designs were developed, trusses became more complex and today, they include large numbers of triangles.
While the addition of trusses increases the strength of a beam, truss bridges also have limits on their maximum practical length.

LONGER BRIDGES

As noted above, a long beam bridge will bend in the middle. Engineers have attempted to overcome this problem in two ways. They have designed bridges so that the weak point of the structure is either pushed up from below by a pier, or pulled up from above by cables. Below, we discuss variations on the beam bridge and review the arch bridge. Each represents a technique used to span wider barriers.

1. Support by making shorter spans.
   Instead of using a long, single span with its inherent problems of bending in the middle, engineers have built bridges made of what are effectively hundreds of small beam bridges joined together. The Chesapeake Bay Bridge-Tunnel in the US is constructed in this way and is known as a continuous span bridge. The bridge, (and tunnel), extend across the shallow Chesapeake Bay for about 26 kilometers, but the largest single span is only 30 meters.

2. Using arches
   The ARCH BRIDGE

The arch was used in structures built by the Egyptian and Chinese civilizations, as well as in the bridges and aqueducts constructed by the Romans.
Construction and materials

The arch makes use of the ability of blocks of stone to withstand very large forces of compression. These forces hold the stones together between the ends (abutments) of the bridge. The central stone in the arch is known as the keystone and all the other stones push against this center stone. The shape of the stones used in the construction of an arch bridge is critical. They must be wedge-shaped, as it is this shape that allows the arch to hold itself up. As time passed and bridge materials improved, arch bridges were made with cast iron, steel, and today, concrete is used.

3a Supporting from below
The CANTILEVER BRIDGE

A cantilever bridge is another variation of a beam bridge. A cantilever is a beam that is supported only at one end. One end of the beam could be anchored firmly to the land while the other end extends out into space, where it would connect with another cantilevered beam to form a whole bridge. Unlike other beam bridges, each beam does not require two piers to support its two ends. This is an advantage in situations where it is difficult to place piers, or where an unrestricted channel is required for shipping. As with beam bridges, however, many cantilever bridges include truss systems for added strength.

The cantilever concept can be easily demonstrated using 5 equal size books (or wood blocks). Stand two books vertically to represent the supporting piers then place a book on each of the piers to represent the cantilever. Each pier and cantilever should look like a letter T. Connect the two cantilevers by balancing a book across the gap or moving the two cantilevers together so they meet.
The Forth Railway Bridge that crosses the wide estuary of the Firth of Forth near Edinburgh, Scotland is one of the world’s largest cantilever bridges, constructed of steel in 1890 with a length of about 2500 meters (approx. 1.5 miles.) Its central span between the two cantilevers, however, is only about 100 meters wide.

In this example, the rail decking has supports both above and below as well as additional support provided by a latticework of triangles.

3b Pulling up from above
The CABLE-STAYED BRIDGE
Cable-stayed bridges are a combination of cantilever and suspension bridges: the road decking of the bridge is the cantilever structure, suspended by cables from a tower. Each tower supports a balanced portion of the deck by way of its cables. While the design idea is not new, this type of bridge became increasingly popular from the mid-20th Century onwards, largely due to developments in the construction materials (pre-stressed concrete). It is also a relatively inexpensive design to build because, unlike a tower-to-tower suspension bridge, it does not require anchorages. As a result, this type of bridge is now selected for many locations where formerly a medium sized (under 1000 meters) suspension bridge would have been built.
Construction and Materials
Cables, attached to a tall tower, are used to support the bridge road decking. The cables run directly from the tower to the deck. All the cables are under tension and the tower supports the total weight of the bridge and everything on it. Towers are typically constructed from concrete or steel, while the cables exhibit great variety in their design.

The SUSPENSION BRIDGE
The concept of a suspension bridge quite possibly dates back to prehistory – vines in forested areas may have been used to construct footbridges across narrow valleys. Today, suspension bridges form some of the longest bridges in the world. Modern suspension bridges use cables strung between two towers – the cables either pass over or through the towers, which support the total weight of the bridge. The ends of the cables are anchored to the ground. The road decking itself is gently arched and has a truss structure to provide additional strength and rigidity. It is suspended from vertical cables called suspenders that hang down from the main cables.

The design of suspension bridges, like any other type of bridge, tries to ensure that the forces acting on the structure are balanced and are working together in harmony. With a suspension bridge, the cables and the suspenders are under tension as they are always being pulled, while the towers are under compression because the cables push down on them.

Fig. 46 - Forces acting on a cable-stayed bridge.
Fig. 47 - Cable designs.
Fig. 48 - The parts of a suspension bridge.
Fig. 49 - The use of trusses on the road decking of a suspension bridge.
The very longest bridges built today are suspension bridges. Currently, the Akashi Bridge linking the Japanese islands of Shikoku and Honshu holds the record, with a length of 3,911 meters (12,515 feet).

**Moving Bridges**

**The BASCULE Bridge**

The word BASCULE is French and means ‘seesaw’. A bascule bridge is one that opens to allow the passage of ships. Its central span is divided and each end is counterbalanced to reduce the effort needed to raise it. The moveable sections that rotate upward are called leaves and are operated by a system of counterweights, gears and motors. The counterweights are typically made from concrete and are normally located below the roadway. A motor turns the gears that move the counterweights down, while the leaves move up and open a passage for shipping.

Tower Bridge, crossing the River Thames in London, England is a bascule bridge. Each bascule is approximately 33 meters (100 feet) long and each has a 422-ton counterweight attached at one end.

**Useful web sites:**

http://www.brantacan.co.uk/ A valuable resource site with detailed information on all aspects of bridge design and construction. Offers an excellent selection of photos and diagrams that can be used in the classroom.

http://www.icomos.org/studies/bridges.htm This site is an excellent library of bridge types from around the world. Heavy on text and very detailed, but a good reference source.

http://eduspace.free.fr/bridging_europe/index.htm A good educational web site with links to other sites. It has informative ideas for lessons and activities.

www.pbs.org/wgbh/buildingbig/bridge/. This web site offers an excellent interactive section where Forces, Loads, Shapes and Materials can be investigated.