# Bridge

اعداد

الدكتور المهندس

عبدالخالق كمال محمود

A **bridge** is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it.

# Types of bridges

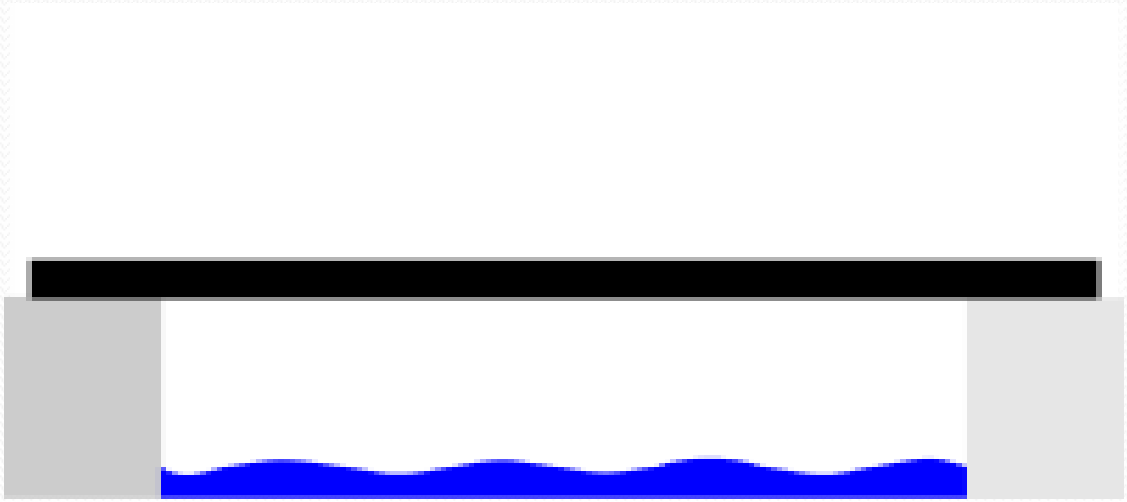
Bridges can be categorized in several different ways. Common categories include the type of structural elements used, by what they carry, whether they are fixed or movable, and by the materials used.

## Structure type

Bridges may be classified by how the forces of tension, compression, bending, torsion and shear are distributed through their structure. Most bridges will employ all of the principal forces to some degree, but only a few will predominate. The separation of forces may be quite clear. In a suspension or cable-stayed span, the elements in tension are distinct in shape and placement. In other cases the forces may be distributed among a large number of members, as in a truss, or not clearly discernible to a casual observer as in a box beam.

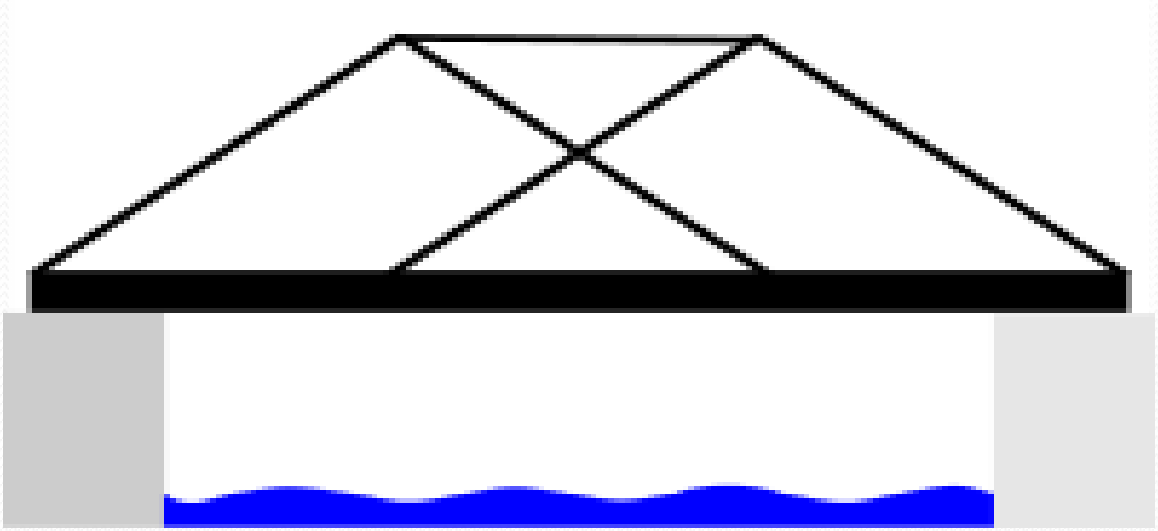
Beam bridges are horizontal beams supported at each end by substructure units and can be either *simply supported* when the beams only connect across a single span, or *continuous* when the beams are connected across two or more spans. When there are multiple spans, the intermediate supports are known as piers. The earliest beam bridges were simple logs that sat across streams and similar simple structures. In modern times, beam bridges can range from small, wooden beams to large, steel boxes. The vertical force on the bridge becomes a shearand flexural load on the beam which is transferred down its length to the substructures on either side[13] They are typically made of steel, concrete or wood. Beam bridge spans rarely exceed 250 feet (76 m) long, as the flexural stresses increase proportional to the square of the length (and deflection increases proportional to the 4th power of the length).[14] However, the main span of the Rio-Niteroi Bridge, a box girder bridge, is 300 metres (980 ft)

# Beam bridge



A truss bridge is a bridge whose load-bearing superstructure is composed of a truss. This truss is a structure of connected elements forming triangular units. The connected elements (typically straight) may be stressed from tension, compression, or sometimes both in response to dynamic loads. Truss bridges are one of the oldest types of modern bridges. The basic types of truss bridges shown in this article have simple designs which could be easily analyzed by nineteenth and early twentieth century engineers. A truss bridge is economical to construct owing to its efficient use of materials

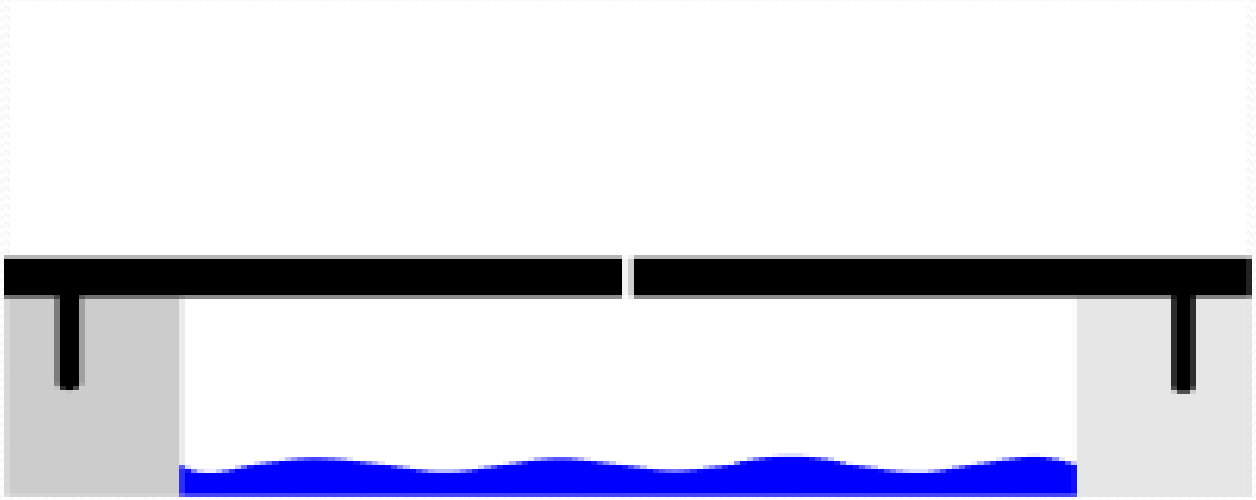
# Truss bridge



Cantilever bridges are built using cantilevers—horizontal beams supported on only one end. Most cantilever bridges use a pair of continuous spans that extend from opposite sides of the supporting piers to meet at the center of the obstacle the bridge crosses. Cantilever bridges are constructed using much the same materials & techniques as beam bridges. The difference comes in the action of the forces through the bridge.Some cantilever bridges also have a smaller beam connecting the two cantilevers, for extra strength.

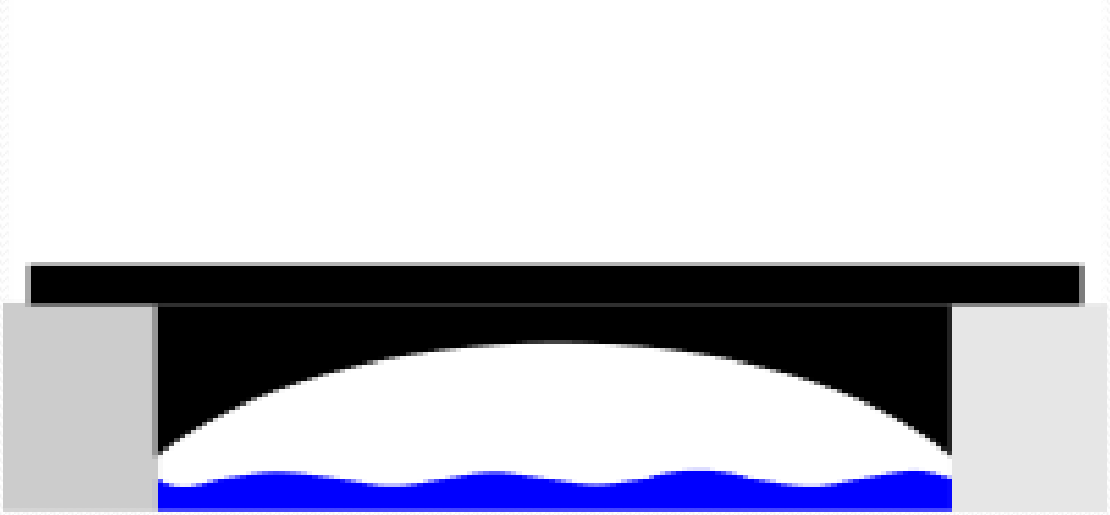
The largest cantilever bridge is the 549-metre (1,801 ft) Quebec Bridge in Quebec, Canada.

# Cantilever bridge



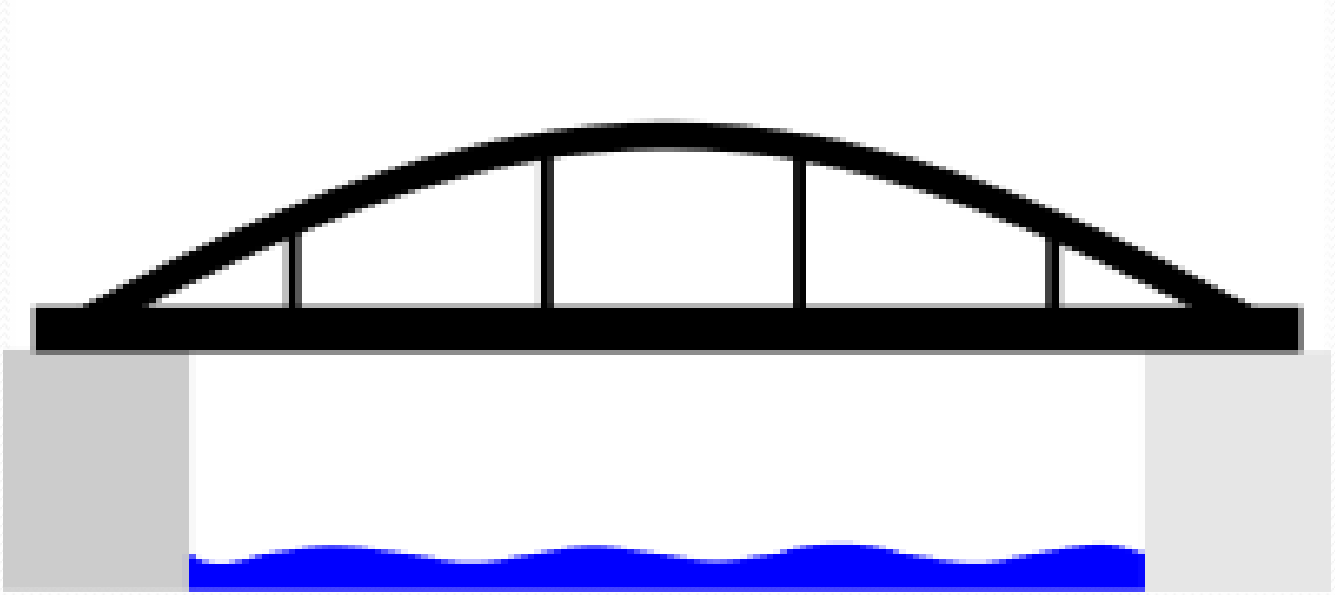
**Arch bridges** have abutments at each end. The weight of the bridge is thrust into the abutments at either side. The earliest known arch bridges were built by the Greeks, and include the Arkadiko Bridge.With the span of 220 metres (720 ft), the Solkan Bridge over the Soča River at Solkan in Slovenia is the second largest stone bridge in the world and the longest railroad stone bridge. It was completed in 1905. Its arch, which was constructed from over 5,000 tonnes (4,900 long tons; 5,500 short tons) of stone blocks in just 18 days, is the second largest stone arch in the world, surpassed only by the Friedensbrücke (Syratalviadukt) in Plauen, and the largest railroad stone arch. The arch of the Friedensbrücke, which was built in the same year, has the span of 90 m (295 ft) and crosses the valley of the Syrabach River. The difference between the two is that the Solkan Bridge was built from stone blocks, whereas the Friedensbrücke was built from a mixture of crushed stone and cement mortar

# Arch bridge



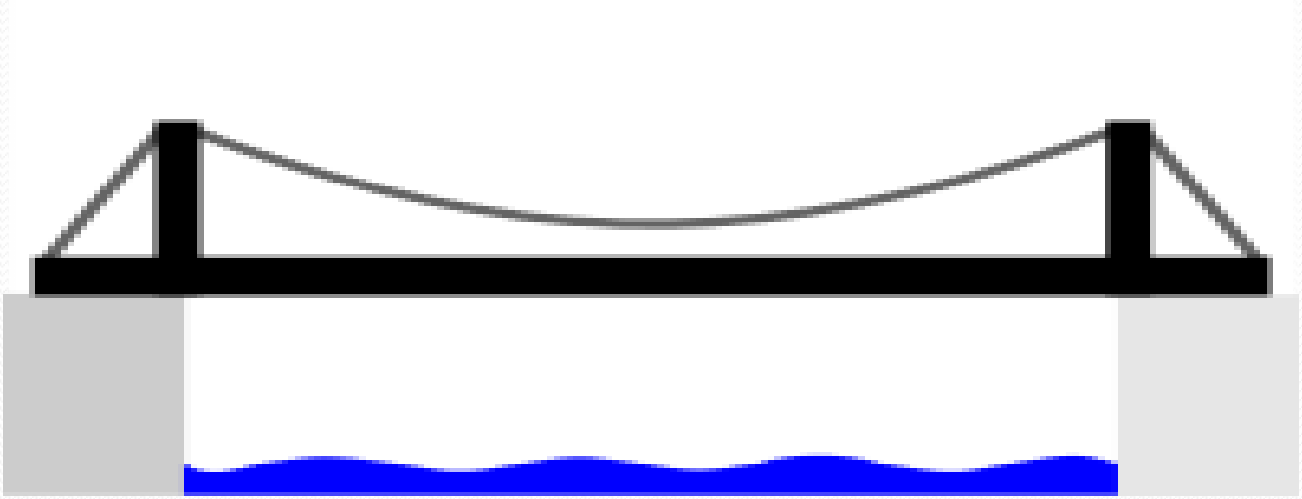
Tied arch bridges have an arch-shaped superstructure, but differ from conventional arch bridges. Instead of transferring the weight of the bridge and traffic loads into thrust forces into the abutments, the ends of the arches are restrained by tension in the bottom chord of the structure. They are also called bowstring arches.

# Tied arch bridge



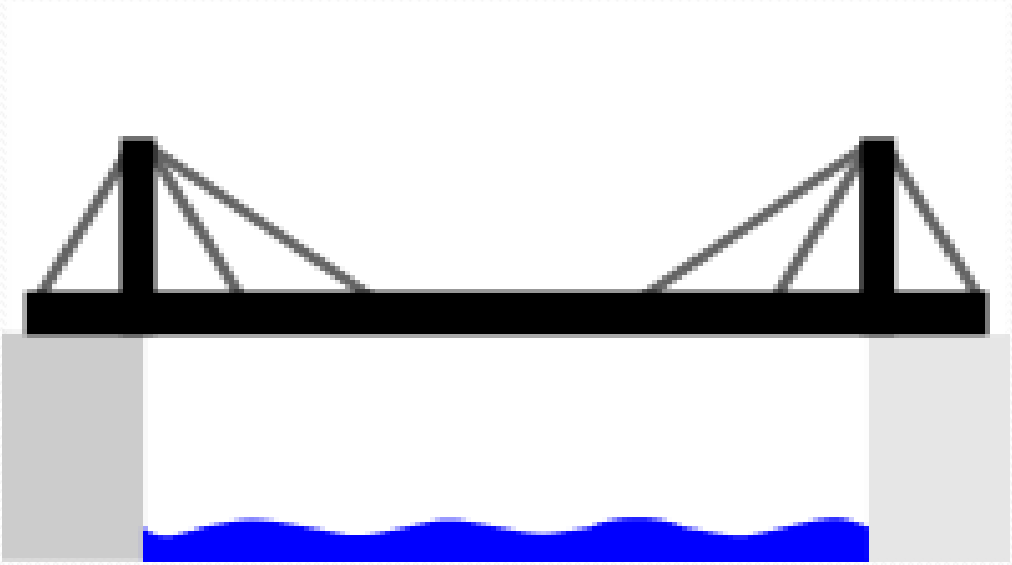
Suspension bridges are suspended from cables. The earliest suspension bridges were made of ropes or vines covered with pieces of bamboo. In modern bridges, the cables hang from towers that are attached to caissons or cofferdams. The caissons or cofferdams are implanted deep into the floor of a lake or river. Sub-types include the simple suspension bridge, the stressed ribbon bridge, the underspanned suspension bridge, the suspended-deck suspension bridge, and the self-anchored suspension bridge.The longest suspension bridge in the world is the 3,909 m (12,825 ft) Akashi Kaikyō Bridge in Japan

# Suspension bridge



Cable-stayed bridges, like suspension bridges, are held up by cables. However, in a cable-stayed bridge, less cable is required and the towers holding the cables are proportionately higher.[19] The first known cable-stayed bridge was designed in 1784 by C. T. (or C. J.) Löscher.[20][21]The longest cable-stayed bridge since 2012 is the Russky Bridge in Vladivostok, Russia

# Cable- stayed bridges



# Fixed or movable bridges

Most bridges are fixed bridges, meaning they have no moving parts and stay in one place until they fail or are demolished. Temporary bridges, such as Bailey bridges, are designed to be assembled, and taken apart, transported to a different site, and re-used. They are important in military engineering, and are also used to carry traffic while an old bridge is being rebuilt. Movable bridges are designed to move out of the way of boats or other kinds of traffic, which would otherwise be too tall to fit. These are generally electrically powered

# Double-decked bridges

Double-decked (or double-decker) bridges have two levels, such as the George Washington Bridge, connecting New York City to Bergen County, New Jersey, USA, as the world's busiest bridge, carrying 102 million vehicles annually;[1][2] truss work between the roadway levels provided stiffness to the roadways and reduced movement of the upper level when the lower level was installed three decades following the upper level. The Tsing Ma Bridge and Kap Shui Mun Bridge in Hong Kong have six lanes on their upper decks, and on their lower decks there are two lanes and a pair of tracks for MTR metro trains. Some double-decked bridges only use one level for street traffic; theWashington Avenue Bridge in Minneapolis reserves its lower level for automobile and light rail traffic and its upper level for pedestrian and bicycle traffic (predominantly students at the University of Minnesota)

# Bridge types by use

A bridge can be categorized by what it is designed to carry, such as trains, pedestrian or road traffic, a pipeline or waterway for water transport or barge traffic. An aqueduct is a bridge that carries water, resembling a viaduct, which is a bridge that connects points of equal height. A road-rail bridge carries both road and rail traffic. A bridge can carry overhead power lines as does the Storstrøm Bridge.[*citation needed*] Some bridges accommodate other purposes, such as the tower of Nový Most Bridge in Bratislava, which features a restaurant, or a bridge-restaurant which is a bridge built to serve as a restaurant. Other suspension bridge towers carry transmission antennas.[*citation needed*]

Bridges are subject to unplanned uses as well. The areas underneath some bridges have become makeshift shelters and homes to homeless people, and the undersides of bridges all around the world are spots of prevalent graffiti. Some bridges attract people attempting suicide, and become known as suicide bridges

# Bridge types by material

The materials used to build the structure are also used to categorize bridges. Until the end of the 18th Century, bridges were made out of timber, stone and masonry. Modern bridges are currently built in concrete, steel, fiber reinforced polymers (FRP), stainless steel or combinations of those materials. Living bridges have been constructed of live plants such as tree roots in India and vines in Japan

| Bridge Type | Materials Used |
| --- | --- |
| Cantilever | For small footbridges, the cantilevers may be simple beams; however, large cantilever bridges designed to handle road or rail traffic use trusses built from structural steel, or box girders built from prestressed concrete.[23] |
| Suspension | The cables are usually made of steel cables coated with Zinc, along with most of the bridge, but some bridges are still made with steel reinforced concrete.[24] |
| Arch | Stone, brick and other such materials that are strong in compression and somewhat so in shear. |
| Beam | Beam bridges can use pre-stressed concrete, an inexpensive building material, which is then embedded with rebar. The resulting bridge can resist both compression and tension forces.[25] |
| Truss | The triangular pieces of Truss bridges are manufactured from straight and steel bars, according to the truss bridge designs.[26] |

# Bridge maintenance

Bridge maintenance consisting of a combination of structural health monitoring and testing. This is regulated in country-specific engineer standards and includes e.g. an ongoing monitoring every three to six months, a simple test or inspection every two to three years and a major inspection every six to ten years. In Europe, the cost of maintenance is higher than spending on new bridges. The lifetime of welded steel bridges can be significantly extended by aftertreatment of the weld transitions . This results in a potential high benefit, using existing bridges far beyond the planned lifetime.

# Bridge failures

The failure of bridges is of special concern for structural engineers in trying to learn lessons vital to bridge design, construction and maintenance. The failure of bridges first assumed national interest during the Victorian era when many new designs were being built, often using new materials.
In the United States, the National Bridge Inventory tracks the structural evaluations of all bridges, including designations such as "structurally deficient" and "functionally obsolete".

# Bridge monitoring

There are several methods used to monitor the stress on large structures like bridges. The most common method is the use of an accelerometer, which is integrated into the bridge while it is being built. This technology is used for long-term surveillance of the bridge.[27]
Another option for structural-integrity monitoring is "non-contact monitoring", which uses the Doppler effect (Doppler shift). A laser beam from a Laser Doppler Vibrometer is directed at the point of interest, and the vibration amplitude and frequency are extracted from the Doppler shift of the laser beam frequency due to the motion of the surface.[28]The advantage of this method is that the setup time for the equipment is faster and, unlike an accelerometer, this makes measurements possible on multiple structures in as short a time as possible. Additionally, this method can measure specific points on a bridge that might be difficult to access.