

# Beam Bridges

**B**eam bridges are the oldest known bridges and tend to be the simplest to design and build. Roughly half of all bridges in the United States are beam bridges. They consist of vertical piers and horizontal beams. A beam bridge's strength depends on the strength of the roadway and can be increased by adding additional piers. While beam bridges can be quite long, the span, or distance between adjacent piers, is usually small.

## ■ Pros and Cons of Beam Bridges ■

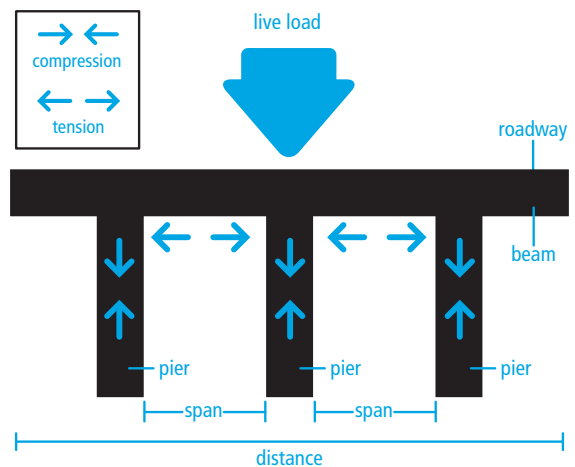
- **Pros:** Easy to build; inexpensive relative to other bridge types; used widely in urban and rural settings
- **Cons:** Limited span; large ships or heavy boat traffic cannot pass underneath; design generally not considered very interesting or eye-catching

## ■ ■ Compression and Tension ■ ■

- **Compression:** As live loads, such as cars and trucks, travel across the bridge, the force of compression acts on the top of the roadway and passes down into the piers.
- **Tension:** The force of tension acts on the underside of the roadway, which is pulled apart by the live loads pressing down on the top of the roadway.



Walter B. Jones Bridge, Hyde County, NC, completed 1981, courtesy North Carolina Department of Traffic



## BRIDGE BRAG

*It's the looooooongest bridge in the world, and it's a beam bridge! The Lake Pontchartrain Causeway in Louisiana is approximately 24 miles long, and its twin spans are supported by more than 9,000 pilings.*

# Arch Bridges

**A**rch bridges were built by the Romans and have been in use ever since. They are often chosen for their strength and appearance. It is the shape of the arch that gives the bridge its strength, which is reinforced by placing supports, or abutments, at its base. Arch bridges can be built from various materials, including wood, stone, concrete, and steel. The famous Italian artist Leonardo da Vinci once said, "An arch consists of two weaknesses, which, leaning on each other, become a strength."

## ■ Pros and Cons of Arch Bridges ■

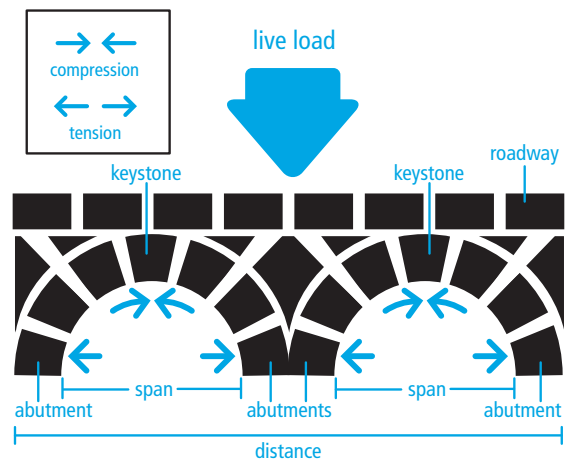
- **Pros:** Wide range of materials can be used; considered attractive; very strong
- **Cons:** Relatively expensive; typically, designs are limited to certain sites (e.g., where the ground can support the large forces at the base of the arch; where the span-to-depth ratio of the arch is proportional; or where an arch is visually appropriate)

## ■ ■ Compression and Tension ■ ■

- **Compression:** The force of compression is greatest at the top of the arch. The abutments press against the bottom of the arch, preventing the bases of the arch from being pushed outward.
- **Tension:** The force of tension is strongest at the bottom of the arch and pulls the sides outward. In general, the larger and shallower the arch, the greater the effects of tension and need for abutment support.



Antietam Aqueduct, Savage, MD, completed 1834, courtesy Lawrence Biemiller



## BRIDGE BRAG

Montgomery Meigs, the architect and engineer of the National Building Museum, also designed the complex Washington aqueduct system. It carries water from the Potomac River over the arched Cabin John Bridge in Maryland to two water processing plants in nearby Washington, D.C. When the bridge was completed in 1863, it was the longest masonry arch in the world. It held the record for 40 years. The main arch has a span of 220 feet, rising 57 feet above a creek.

# Truss Bridges

**W**ooden truss bridges were used as early as the 1500s, but the first metal one was completed in 1841. They are very strong and have been used for railroad bridges mainly because of the heavy loads that they can support. A truss, a rigid support structure that is made up of interlocking triangles, holds up the roadbed and is set between two piers. The triangle is used because it is the only shape that is inherently rigid.

## ■ Pros and Cons of Truss Bridges ■

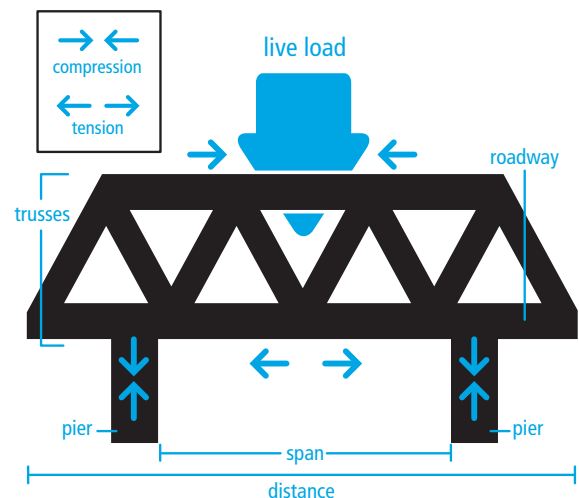
- **Pros:** Very strong; frequently used as a draw bridge or as an overpass for railroad trains
- **Cons:** Difficult to construct; high maintenance; difficult to widen if necessary; generally not considered attractive

## ■ ■ Compression and Tension ■ ■

- **Compression:** As traffic pushes down on the roadway, compression acts on the upper horizontal members of the truss structure.
- **Tension:** Tension acts on the bottom horizontal members of the truss structure. The forces of tension and compression are shared among the angled members.



George Street Bridge, Aurora, IN, completed 1887, courtesy Indiana Department of Transportation



## BRIDGE BRAG

*It's difficult to see the trusses on some of America's best-known truss bridges, the covered bridges that were common in the rural Northeast. The roofs were not constructed to protect people from severe weather, but to preserve the truss system itself. Wooden bridges without roofs would last 10 to 15 years, but covering the bridge extended its life to 70 or 80 years.*

# Suspension Bridges

**S**uspension bridges are strong and can span long distances. One early bridge was designed and built in 1801 in Pennsylvania. They are expensive because they take a long time to build and require a large amount of material. They are commonly found across harbors with a lot of boat traffic. The primary elements of a suspension bridge are a pair of main cables stretching over two towers and attached at each end to an anchor. Smaller cables attached to the main cables support the roadway.

## ■ Pros and Cons of Suspension Bridges ■

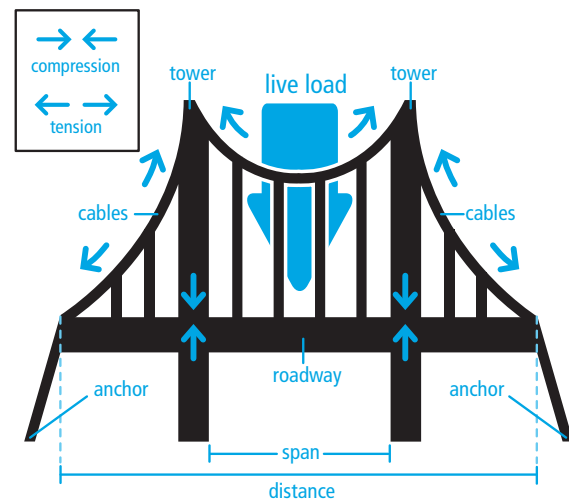
- **Pros:** Span distances up to 7,000 feet; considered attractive; allow large ships and heavy boat traffic to pass underneath
- **Cons:** Expensive (require a long time and a large amount of material to build)

## ■ ■ Compression and Tension ■ ■

- **Compression:** Traffic pushes down on the roadway, but because it is suspended from the cables, the weight is carried by the cables, which transfer the force of compression to the two towers.
- **Tension:** The force of tension is constantly acting on the cables, which are stretched because the roadway is suspended from them.



Golden Gate Bridge, San Francisco, CA, completed 1937, used with permission from The Golden Gate Bridge, Highway and Transportation District, San Francisco, CA, [www.goldengatebridge.org](http://www.goldengatebridge.org)



## BRIDGE BRAG

*The Tacoma Narrows suspension bridge in Washington State was known as “Galloping Gertie” because it rippled like a roller coaster. Completed in July 1940, the first heavy storm four months later caused the bridge to break and collapse from wind-induced vibrations. It was replaced by a stiffer bridge, which has proven to be satisfactory.*

# Cable-Stayed Bridges

The first modern cable-stayed bridge was completed in Sweden in 1956. Cable-stayed bridges were created as an economical way to span long distances. This bridge's design and success were made possible as new materials and construction techniques were developed. Cable-stayed bridges have one or more towers, each of which anchors a set of cables attached to the roadway.

## ■ Pros and Cons of Cable-Stayed Bridges ■

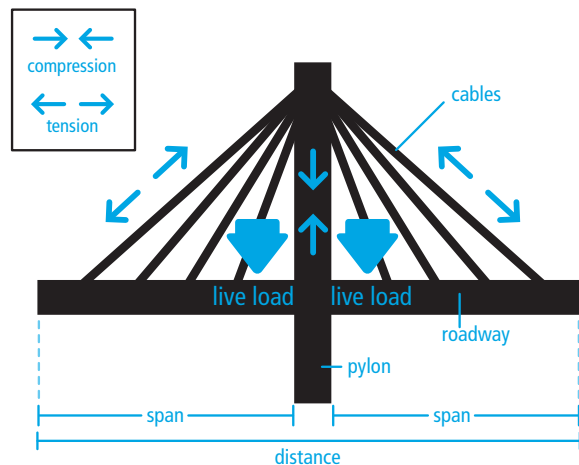
- **Pros:** Span medium distances (500–2,800 feet); less expensive and faster to build than suspension bridges; considered attractive
- **Cons:** Typically more expensive than other types of bridges, except suspension bridges

## ■ ■ Compression and Tension ■ ■

- **Compression:** As traffic pushes down on the roadway, the cables, to which the roadway is attached, transfer the load to the towers, putting them in compression.
- **Tension:** The force of tension is constantly acting on the cables, which are stretched because they are attached to the roadway.



Fred Hartman Bridge, Baytown/Laporte, TX, completed 1995, courtesy Kevin Stillman, Texas Department of Transportation



## BRIDGE BRAG

America's longest cable-stayed bridge, the Cooper River Bridge in Charleston, South Carolina, opened in summer 2005. It is approximately 2.5 miles long and 186 feet above the river. The central span between the two towers is 1,546 feet, and the towers themselves rise 575 feet above the water line.