The Basic Types of Bridges

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Section 1 — Definition

Overview

A bridge is a structure built to span a physical obstacle (such as a body of water, valley, road, or rail) without blocking the way underneath. It is constructed for the purpose of providing passage over the obstacle, which is usually something that is otherwise difficult or impossible to cross. There are many different designs of bridges, each serving a particular purpose and applicable to different situations. The design of bridges varies depending on factors such as the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, and the material used to make it, and the funds available to build it.

History

Bridges have played a prominent role in developing transportation, communication, and international and local trade since the dawn of time. Bridges connect lands disconnected by water overcoming the obstacle smoothly. The simplest and earliest types of bridges were stepping stones. Neolithic people also built a form of boardwalk across marshes; examples of such bridges include the Sweet Track and the Post Track in England, approximately 6000 years old. Undoubtedly, ancient people would also have used log bridges (timber bridges) that fall naturally or are intentionally felled or placed across the streams. Some of the first man-made bridges with significant span were probably intentionally felled trees.

Among the oldest timber bridges is the Holzbrücke Rapperswil-Hurden crossing upper Lake Zürich in Switzerland; the prehistoric timber piles that were discovered to the west of the Seedamm, date back to 1523 BC. The first wooden footbridge led across Lake Zürich, followed by several reconstructions at least until the late 2nd century AD, when the Roman Empire built a 6-meter-wide (20 ft) wooden bridge. Between 1358 and 1360, Rudolf IV, Duke of Austria, built a 'new' wooden bridge across the lake that has been used to 1878 – measuring approximately 1,450 meters (4,760 ft) in length and 4 meters (13 ft) wide. On April 6, 2001, the reconstructed wooden footbridge was opened, being the longest wooden bridge in Switzerland.

The Arkadiko Bridge is one of four Mycenaean corbel arch bridges part of a former network of roads, designed to accommodate chariots, between the fort of Tiryns and town of Epidauros in the Peloponnese, in southern Greece. Dating to the Greek Bronze Age (13th century BC), it is one of the oldest arch bridges still in existence and use. Several intact arched stone bridges from the Hellenistic era can be found in the Peloponnese.

The greatest bridge builders of antiquity were the ancient Romans. The Romans built arch bridges and aqueducts that could stand in conditions that would damage or destroy earlier designs. Some stand today. An example is the Alcántara Bridge, built over the river Tagus, in Spain. The Romans also used cement, which reduced the variation of strength found in natural stone. One type of cement, called Pozzolana, consisted of water, lime, sand, and volcanic rock.

Brick and mortar bridges were built after the Roman era, as the technology for cement was lost (then later rediscovered).

In India, the Arthashastra treatise by Kautilya mentions the construction of dams and bridges. A Mauryan bridge near Girnar was surveyed by James Princep. The bridge was swept away during a flood, and later repaired by Puspagupta, the chief architect of emperor Chandragupta I. The use of stronger bridges using plaited bamboo and iron chain was visible in India by about the 4th century. A number of bridges, both for military and commercial purposes, were constructed by the Mughal administration in India.

Although large Chinese bridges of wooden construction existed at the time of the Warring States period, the oldest surviving stone bridge in China is the Zhaozhou Bridge, built from 595 to 605 AD during the Sui dynasty. This bridge is also historically significant as it is the world's oldest open-spandrel stone segmental arch bridge. European segmental arch bridges date back to at least the Alconétar Bridge (approximately 2nd century AD), while the enormous Roman era Trajan's Bridge (105 AD) featured open-spandrel segmental arches in wooden construction.

Rope bridges, a simple type of suspension bridge, were used by the Inca civilization in the Andes mountains of South America, just prior to European colonization in the 16th century.

The Ashanti built bridges over streams and rivers. They were constructed by pounding four large forked tree trunks into the stream bed, placing beams along these forked pillars, then positioning cross-beams that were finally covered with four to six inches of dirt.

During the 18th century, there were many innovations in the design of timber bridges by Hans Ulrich Grubenmann, Johannes Grubenmann, and others. The first book on bridge engineering was written by Hubert Gautier in 1716.

A major breakthrough in bridge technology came with the erection of the Iron Bridge in Shropshire, England in 1779. It used cast iron for the first time as arches to cross the River Severn. With the Industrial Revolution in the 19th century, truss systems of wrought iron were developed for larger bridges, but iron does not have the tensile strength to support large loads. With the advent of steel, which has a high tensile strength, much larger bridges were built, many using the ideas of Gustave Eiffel.

In Canada and the United States, numerous timber covered bridges were built in the late 1700's to the late 1800's, reminiscent of earlier designs in Germany and Switzerland. Some covered bridges were also built in Asia. In later years, some were partly made of stone or metal but the trusses were usually still made of wood; in the United States, there were three styles of trusses, the Queen Post, the Burr Arch, and the Town Lattice. Hundreds of these structures still stand in North America. They were brought to the attention of the general public in the 1990's by the novel, movie, and play The Bridges of Madison County.

In 1927, welding pioneer Stefan Bryła designed the first welded road bridge in the world, the Maurzyce Bridge which was later built across the river Słudwia at Maurzyce near Łowicz, Poland in 1929. In 1995, the American Welding Society presented the Historic Welded Structure Award for the bridge to Poland.

Section 2 — Types of Bridges by Classification

Bridges are classified based on design structure and material used. There are several types of bridges from ancient times until now. In this course, the most prominent kinds of bridges are discussed in detail.

1. Arch Bridges
2. Tied-Arch Bridges
3. Beam Bridges
4. Cantilever Bridges
5. Suspension Bridges
6. Cable-Stayed Bridges
7. Truss Bridges

Arch Bridges

Overview

There are many different types of arch bridge but they all have central elements in common. Each bridge has abutments, which are used to support the curved arch structure under the bridge. (Refer to Figure 1).

Arch bridges were extensively used by ancient Romans and are the most popular types of bridges. This bridge is in the shape of an arch, as the name suggests. The loads are carried along the arch's curve to the support's end because the curve's load is not applied directly straight down. This means a high amount of pressure does not affect any part of the bridge. Abutments are the supports that take the load of the entire bridge. Depending on the stress and loads that the bridge should support, there will be several curves in the bridge. The arch structure has a roadway, and its span length is up to 250 meters (short span range).

The most common type of arch bridge is a viaduct, a long bridge made up of many arches. The lateral pressure created by the arch span is transferred into the supporting abutments.

Figure 1 Example of an Arch Bridge: Gaoliang Bridge of The Summer Palace

It is therefore essential that these parts of the bridge remain solid, intact, and well founded. Many arch bridges have decorative brickwork, which is an integral part of the design. Simple yet so very effective an arch bridge can carry everything from pedestrians to heavy rail.

Material

Stone, Concrete, Steel.

Advantages

1. These types of bridges are easy to build with the materials available locally.
2. These types of bridges are solid and rigid.

Disadvantages

1. It takes a long time to build these bridges.
2. These types of bridges consume a massive amount of materials.

Tied Arch Bridge (Bowstring)

Overview

The tied arch bridge is a fascinating design which incorporates an arch structure (usually metal) supported by vertical ties between the arch and the deck (Refer to Figure 2). The tips of the arch structure are connected by a bottom chord. This acts in a similar fashion to the string of a bow. The downward pressure from the arch structure to the deck of the bridge is translated into tension by the vertical ties. Many people assume that the abutments ensure that the tied arch bridge and the arch structure stay in place. However, it is the decking/strengthened chord which connects the tips of each end of the arch together. The best example of this is a bowstring which absorbs pressure, keeping both sides of the bow in contact, until it eventually flattens out.

This bridge structure incorporates an arch supported by vertical ties between an arch and the deck is called the tied arch bridge, a fascinating design. The bottom chord connects the tips of the arch structure, which has similar functioning to a bow's string. The vertical lines translate the tension by the downward pressure from the arch structure to the bridge's deck. The strengthened chord connects the arch with the tips of each end. The span range is long.

Figure 2 Example of a Tied Arch Bridge: Infinity Bridge in Stockton-on-Tees

A comparison between an arch bridge and a tied arch bridge is illustrated in Figure 3.

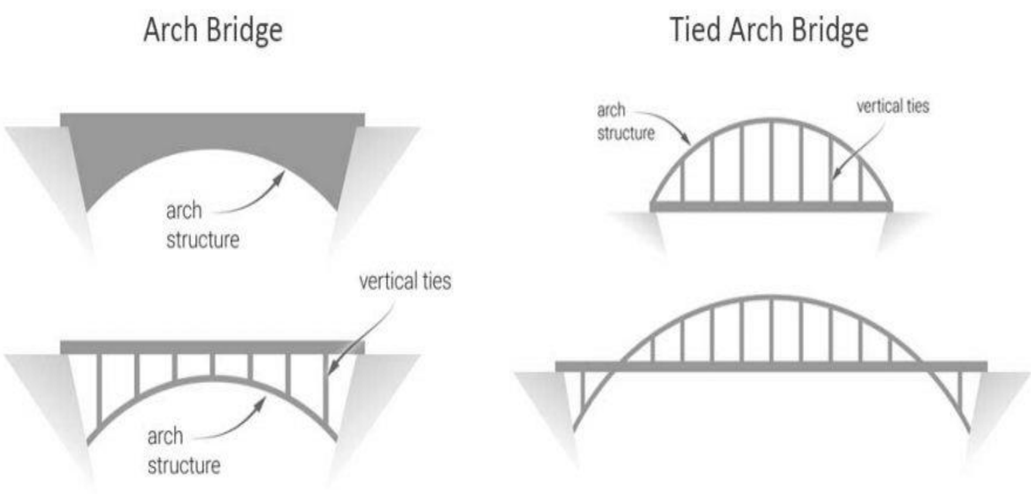

Figure 3 Comparison of Arch Bridge and Tied Arch Bridge Diagrams

Material

Stone, concrete, bricks, and steel.

Advantages

1. These types of bridges are very resistant to failure.
2. These types of bridges are solid and can take a high amount of pressure.
3. These bridges become more robust with each visit since they are built to compress.

Disadvantages

1. These types of bridges are not economical.
2. These types of bridges need varied construction materials.
3. These types of bridges require regular maintenance.
4. These types of bridges need more time compared to other conventional bridges.

Beam Bridges

Overview

A beam bridge is one of the simplest types of bridge. A perfect example being a basic log bridge – something that could be seen while out on a country walk.

The deck area traditionally consists of wood plank or stone slabs (often referred to as a clapper bridge). These are supported either side by two beams running between abutments/piers. (Refer to Figure 4). The span range is short.

Very often, other beams are found, positioned in between the main beams, offering additional support and stability.

A beam bridge is a perfect example of an essential log bridge and is one of the simplest ones. Wood plank or stone slabs are some of the materials used to build the deck traditionally. Two beams running between the abutments support the bridge on either side. It offers additional support and stability by adding other beams between the main beams. Unlike the other bridges, a beam bridge does not have stress transfer.

The area over which people or vehicles travel will be a simple decking positioned vertically across the underlying beams. This is often referred to as a "simply supported" structure (Refer to Figure 5). There is no transfer of stress that is observed in arch structures and other types of bridges.

Figure 4 Example of a Beam Bridge: Iowa River Bridge

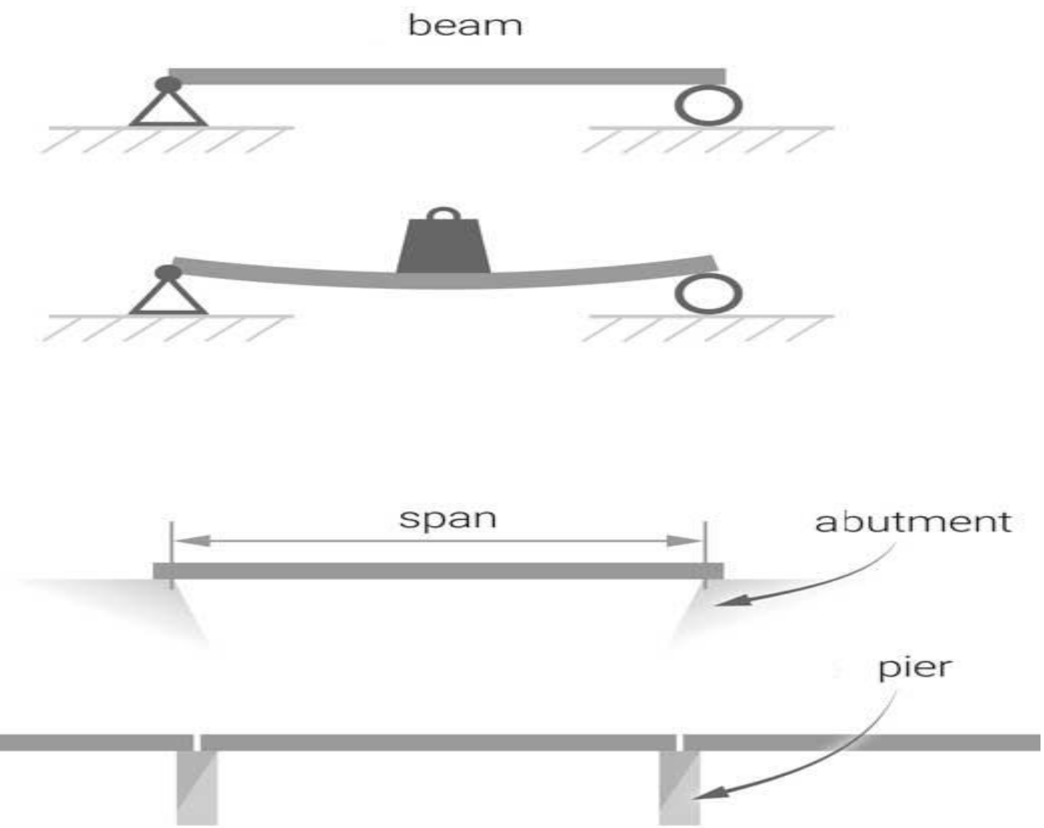

Figure 5 Beam Bridge Diagram

Material

Concrete and steel.

Advantages

1. These types of bridges are easy to construct and erect.
2. These types of bridges are the best for short-span.
3. These types of bridges can cover vast distances.
4. These types of bridges are ease in construction of temporary bridges.

Disadvantages

1. These types of bridges require reinforced concrete cement (RCC).
2. These types of bridges are expensive to build.
3. Limits span these bridges.

Cantilever Bridges

Overview

When the first cantilever bridge was designed it was seen as a major engineering breakthrough. The bridge works by using cantilevers which may be simple beams or trusses. They are made from prestressed concrete or structural steel when used to accommodate traffic (Refer to Figure 6). When the horizontal beams making up the cantilever arm are considered as only supported from one side, it does begin to sound a little dangerous. However, the two cantilever arms are connected by what is known as the "suspended span" which is effectively a centerpiece which has no direct support underneath. The bridge load is supported through diagonal bracing with horizontal beams as opposed to typical vertical bracing (Refer to Figure 7). Extremely safe and very secure, the design of cantilever bridges is one which still lives on today. The span range is medium.

Figure 6 Example of a Cantilever Bridge: Forth Bridge, Scotland

A cantilever bridge has one end kept free in space while the other has support. But this does not mean one end is completely free. The two free ends connect the suspended deck during the construction of the cantilever bridges. The top supports are applied to a tensional force when the load is applied. At the same time, the compression force is applied to the bottom parts. This process helps with the balance of the cantilever bridge. The bridge is stable as long as there is balance in the force. This bridge has a 150 m – 500 m span.

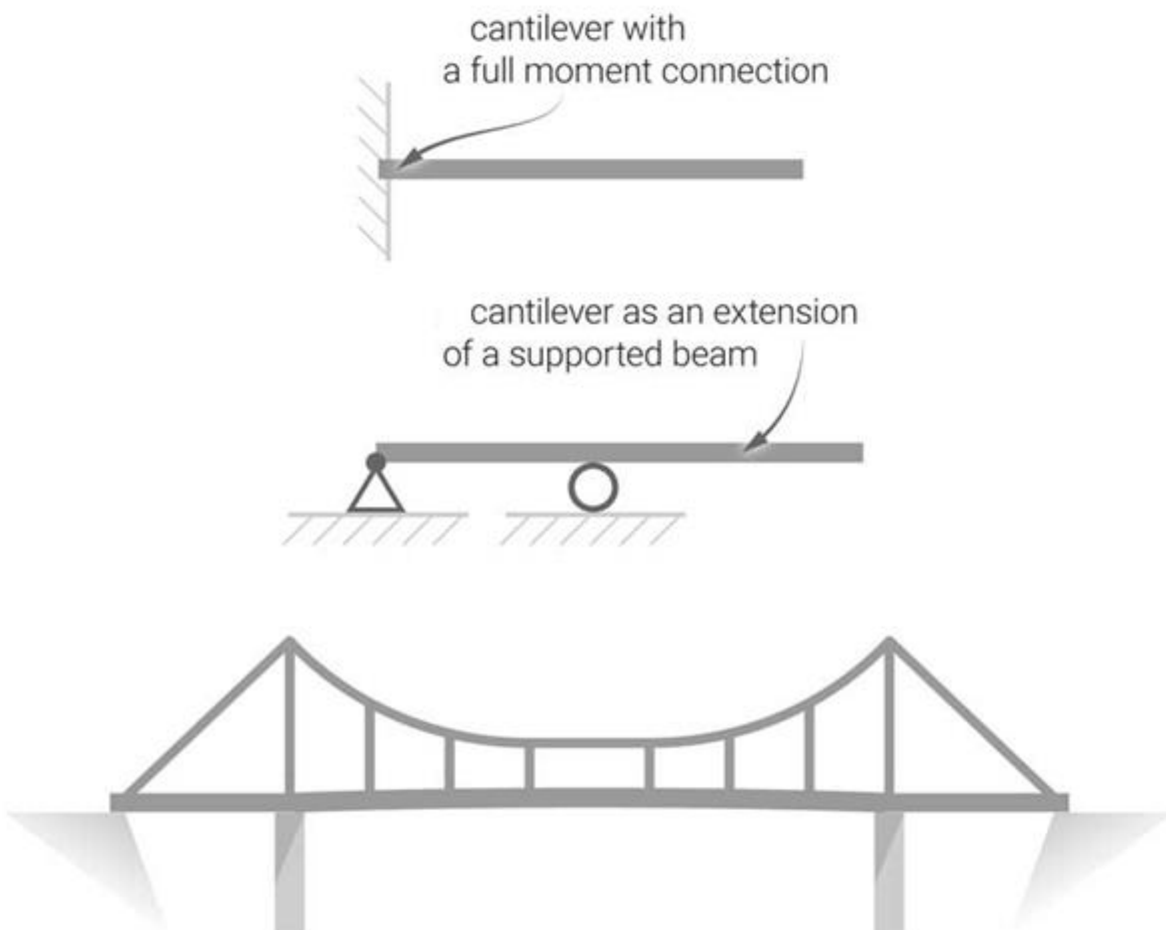

Figure 7 Cantilever Bridge Diagram

Material

Structural steel, prestressed concrete, and iron.

Advantages

1. These types of bridges require support only on one side.

2. These types of bridges are constructed when support cannot be provided.

Disadvantages

1. During construction, cantilever bridges are prone to high turning stress.
2. These types of bridges might buckle if the forces are not balanced.

Suspension Bridges

Overview

The structure of a stereotypical suspension bridge looks very simple but the design is extremely effective (Refer to Figure 8). The deck of the suspension bridge is the load-bearing element of the structure. This is held in place by vertical suspenders which support the cables. The suspension cables extend out beyond each side of the bridge and are anchored firmly into the ground. It will depend upon the size of the bridge but a number of towers will be installed to hold up the suspension cables. Any load applied to the bridge is transformed into tension across the suspension cables which are the integral part of the structure. As there is some “give” in the suspension cables this can translate into slight, but measured, bridge movement in difficult weather conditions.

Figure 8 Example of a Suspension Bridge: Akashi Kaikyō Bridge in Japan

Suspension bridges use suspension cables to suspend the deck slab. The steel cables hang the roadways secured by anchors on both ends of the bridge while connecting the two towers with steel cables. The span range is medium to long.

The compression is dissipated into the earth by anchors with the help of towers. The cables or chains transfer the compression to the towers with the load applied to the suspension bridge by traveling up the ropes, cables, or chains. The suspension bridge length span is between 150 m to 2000 m.

Material

Multiple steel wire strand cables, forged or cast chain links, and steel ropes.

Advantages

1. These types of bridges are lightweight and strong.
2. These types of bridges help to cross the river by providing a long span.

Disadvantages

1. These types of bridges are expensive.
2. These types of bridges sway and ripple with the wind.
3. These types of bridges are not suitable for railways.

Cable-Stayed Bridges

Overview

A cable stayed bridge is dependent upon towers/pylons which are the load-bearing element of the structure. Cables are connected from the pylons to the deck below, either directly from the top of the tower or at different points of the column (Refer to Figure 9). When connected at different points of the column this creates a fan like pattern. This is the feature many people associate with cable stayed bridges. This type of structure tends to be used for distances greater than those achieved with a cantilever bridge design but less than a suspension bridge. One of the main issues with this type of bridge is that the central connection of the cables can place horizontal pressure on the deck. Therefore, the deck structure needs to be reinforced to withstand these ongoing pressures.

Cable-stayed bridges are similar to suspension bridges but modern ones. Instead of suspended cables, these bridges are connected directly to the tower. The cables attached to the roadways create tension. A single tower covers the entire compression of the bridge as it doesn't have any anchorages. The cable-stayed bridge has a length span of 500 meters to 1000 meters (medium span range).

Material

Steel or concrete pylons, steel rope, post-tensioned concrete box grinders.

Advantages

Compared to a suspension bridge, it is economical.

1. These types of bridges are built easily.

2. These types of bridges are effective for medium spans.

Disadvantages

1. These types of bridges might not be easy to inspect and maintain the bridge.
2. These types of bridges are not suitable for long distances.

Figure 9 Example of a Cable-Stayed Bridge: The Rio Antirrio Bridge in Greece

A comparison between suspension bridges and cable-stayed bridges is illustrated in Figure 10.

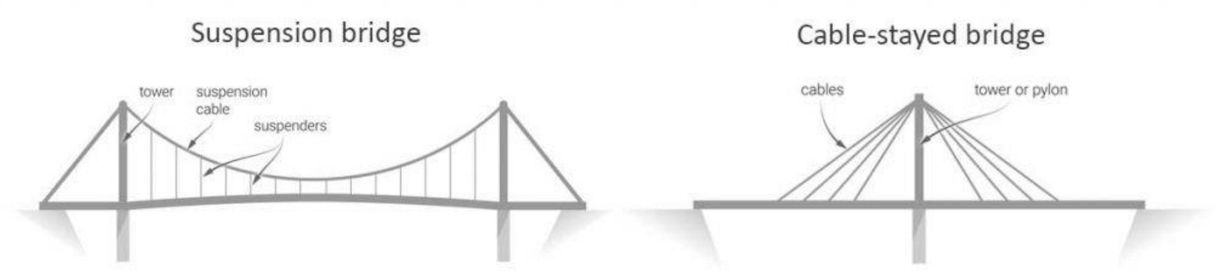

Figure 10 Comparison of Suspended and Cable-Stayed Bridges Diagram

Truss Bridges

Overview

The truss bridge has been around for literally centuries and is a load-bearing structure which incorporates a truss in a highly efficient yet very simple design. An array of different variations of the simple truss bridge is noticed, but they all incorporate triangular sections (Refer to Figure 11). The role of these triangular elements is important because they effectively absorb tension and compression to create a stressed structure able to accommodate dynamic loads (Refer to Figure 12). This mixture of tension and compression ensures the structure of the bridge is maintained and the decking area remains uncompromised even in relatively strong winds. The span range is short to medium.

Figure 11 Example of a Truss Bridge: Francis Scott Key Bridge, Baltimore

Figure 12 Truss Bridge Diagram

A truss bridge consists of struts in the form of a framework. Many small elements form triangular trusses that create this bridge, hence the name. These bridges can support heavy loads as they are very rigid. Compared to the other type of bridges, the weight of the truss bridge is significantly less. The truss bridge has a span length of 50 m to 110 m.

Material

Iron, timber, prestressed concrete, and reinforced concrete.

Advantages

1. These types of bridges are built in the factory and framed on the site.
2. The piers or supports of these types of bridges are comparatively less.

3. These types of bridges are rigid and robust.
4. These types of bridges are very lightweight.

Disadvantages

1. The design of these types of bridges requires highly skilled professionals.
2. The design of these types of bridges is more complex.

Section 3 — Types of Bridges by Mobility

Fixed Bridges

Overview

Fixed bridges are the ones that provide a steady, secure passage across a river, canyon, rail line, roadway, or any other obstacle by anchoring in place and are pretty simple (Refer to Figure 13).

Figure 13 Example of a Fixed Bridge

Temporary Bridges

Overview

Pontoon bridges (floating bridges) help transport supplies, military vehicles, and troops during wartime. These are temporary structures that float directly on the water atop pontoons. Earlier, to form a bridge, people lined up ships or rafts for this purpose (Refer to Figure 14).

Figure 14 Example of a Temporary Bridge

Material

Lightweight aggregate concrete, high-performance steel, and aluminum.

Advantages

1. These types of bridges are quick construction.
2. These types of bridges are inexpensive.
3. These types of bridges are durable.
4. These types of bridges can cope with vehicles and pedestrians.

Disadvantages

1. These types of bridges require high-cost maintenance.

2. These types of bridges are susceptible to damage because of weather.
3. Navigation of watercraft is obstructed.

Movable Bridges

Overview

As the name suggests, movable bridges allow a portion of the structure to move, such as swinging and lifting bridges (Refer to Figure 15). The span range is short.

Figure 15 Example of a Movable Bridge

Some examples of movable bridges are:

1. Vertical Lift Bridge
   This truss bridge uses cables affixed to the deck while raising the bridge. In addition, there are towers on either side of the waterway, and these bridges use pulleys to raise the bridge. The height of the towers dictates the maximum size as the deck remains horizontal as it is raised.

2. Swing Bridges
   Swing bridges swing like an opening door or rotate horizontally on a pedestal allowing watercraft to pass. These types of bridges are used in places where you cannot construct a lift bridge; although these types of bridges are not very common.

Section 4 — Types of Bridges by Function

Pedestrian Bridges

Overview

Pedestrian bridges are wide enough for a single person or two people side-by-side and are also called footbridges (Refer to Figure 16). The earliest pedestrian bridges include fallen trees or stepping stones. Roads that transverse lower, marshy, or sandy land, such as swinging bridges and boardwalks, come under pedestrian bridges.

Figure 16 Example of a Pedestrian Bridge

Material

Steel, concrete, fiber reinforced polymer (FRP), wood, composite, and aluminum.

Advantages

1. These types of bridges give access to beautiful views.

2. These types of bridges help enhance nature's beauty.
3. These types of bridges have safe crossings in urban areas.
4. These types of bridges are accessible for disabled.
5. These types of bridges have year-round access.

Disadvantages

1. These types of bridges cost more to implement in remote areas.
2. These types of bridges might increase the cost to incorporate accessibility to long ramps.
3. These types of bridges provide limited bridge maintenance.

Double-Decked Bridges

Overview

A double-decker bridge is ideal for densely populated areas to accommodate more traffic (Refer to Figure 17). The upper deck allows freeway traffic featuring six lanes for each direction and two lanes for non-motorized vehicles. It also has four local motor vehicle lanes and two more pedestrian walkways.

Figure 17 Example of a Double-Decked Bridge

Train Bridges

Overview

Trains bridges are nothing but truss bridges, and many truss bridges carry rail lines (Refer to Figure 18). They became prominent for transportation when railroads were the pinnacle. Trestle is another train bridge supported by frames close to a long span and consists of multiple short beams end-to-end. Steel, concrete, stone, and asphalt are some materials for constructing this bridge.

Figure 18 Example of a Train Bridge

Pipeline Bridges

Overview

A bridge constructed for running a pipeline over a river or another obstacle is called a pipeline bridge (Refer to Figure 19). These bridges are built when there is no possibility of running a pipeline under the river or conventional bridges. This type of bridge uses thermoplastics, steel, fiber glass, and aluminum for construction, and are usually suspension bridges.

Figure 19 Example of a Pipeline Bridge

Aqueduct/Viaduct Bridges

Overview

Aqueduct is constructed to convey watercourses across gaps such as ravines or valleys and therefore are also called water bridges. The word aqueduct means 'water bridge' in Latin. Romans carried water from one place to another by using arched aqueducts.

A viaduct is a series of aches over an extended distance that elevates a roadway perfectly. This road supports a long elevated railway or road and consists of a series of arches, piers, or columns (Refer to Figure 20). The span range is long.

Figure 20 Example of an Aqueduct/Viaduct Pipeline Bridge

Culvert Bridges

Overview

Culverts are similar to bridges but are not technically bridges. These structures allow water to flow underneath rather than across the road, trail, or rail line, and are simple structures surrounded by soil or other fill (Refer to Figure 21).

Material

High-density polyethylene, aluminum, steel, plastic, and concrete.

Advantages

1. Culverts prevent erosion.
2. Culverts help prevent floods.
3. Culverts do not allow water to overflow.
4. Culverts help divert water for engineering or farming purposes.

Disadvantages

1. If the shape of the construction is poor, there might be a prohibition on the growth of aquatic organisms.
2. There is a chance of severe corrosion or scouring if the installation is incorrect.

Figure 21 Example of a Culvert Bridge

Traffic Bridges

Overview

A traffic bridge allows at least one vehicle to transverse in a single direction because it is wide and sturdy; Although usually there are at least two lanes of opposing traffic and the traffic bridge accommodates it (Refer to Figure 22).

Figure 22 Example of a Traffic Bridge

Section 5 — Additional Types of Bridges

Clapper Bridges

Overview

The clapper bridge is an ancient form of bridge in which large flat stone slabs (often schist or granite) rest on piles of stones (Refer to Figure 23). Most of them were built in medieval times to carry a trackway across a river and the span range is short.

Figure 23 Postbridge Dating from the 13th Century

Natural Bridges

Overview

Many naturally created arch formations resemble a bridge (Refer to Figure 24). Those bridges could have been formed from river flow, wind erosion, or collapse of lava tubes; the span range of these bridges is short.

Figure 24 A 92-foot Tall Natural Arch, Azure Window

Covered Bridges

Overview

The term 'covered bridge' refers to a specific kind of structure, not just any bridge with a roof. It is a timber-truss bridge that distributes the weight of the load-bearing deck. They are covered to protect the wood materials from the weather (Refer to Figure 25).

Uncovered wooden bridges usually last only 20 years due to the effects of rain and sunlight. When they are externally covered, their lifespan increases up to 100 years.

At present, there are nearly 1,600 covered bridges in the world (that are still in use). Most of them are built to cross streams and have a short span.

Figure 25 The Longest Covered Bridge is 1,282-feet Long | Hartland Bridge in New Brunswick

Through Arch Bridges

Overview

These types of bridges are the most common forms of arch bridges, which top rises above the deck and the base remains below or at the deck.

The middle segment of the deck is supported by the arch via tie bars or suspension cables.

The ends of the bridge are usually supported from below (Refer to Figure 26). These types of bridges have long spans.

Sydney Harbor Bridge (in Australia), Tyne Bridge (in North East England), and Bayonne Bridge (in New York) are some well-known examples of through arch bridges.

Figure 26 World's 5th Longest Steel Arch Bridge | Bayonne Bridge

Moon Bridges

Overview

These are pedestrian bridges, of which the semicircular arch completes a 360-degree circle through its reflection in the water, and reminds of the full moon (Refer to Figure 27). These structures were originated in the Asian culture. Initially, they were constructed in China and later introduced to Japan.

Figure 27 Jade Belt Bridge in Beijing, China

Moon bridges are mostly made of stone, wood, and metal. Since they are steep, they have the advantage of not using space from the adjoining fields. It is the perfect way to allow foot traffic above the structure and boat traffic beneath, without requiring a gradual approach for the bridge. These types of bridges have short spans.

Stressed Ribbon Bridges

Overview

Stressed ribbon bridges (also called a catenary bridges) are tension structures. They have two or more suspension cables embedded in the deck. These cables follow a catenary arc (a curved formed by a freely-hanging wire) between supports and provide stiffness to the bridge (Refer to Figure 28). These types of bridges have medium spans.

The structure is usually made of concrete reinforced by steel tensioning cables. These bridges are very aesthetic, economical, almost maintenance-free structures.

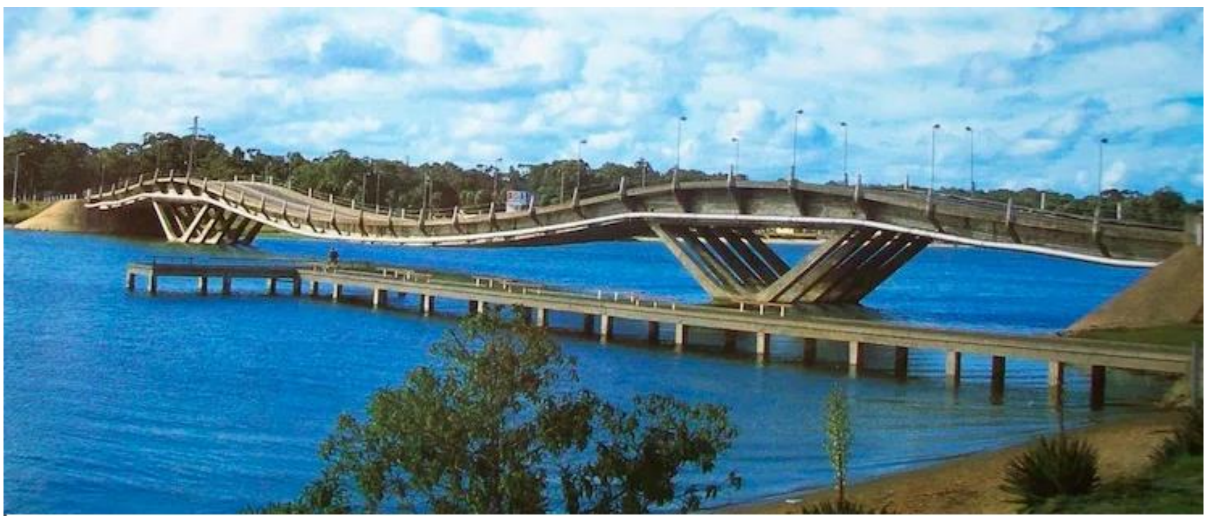

Figure 28 Leonel Viera Bridge | The First Stressed-Ribbon Bridge Constructed in Uruguay in 1965

Spiral Bridges

Overview

A spiral bridge loops over its own road and is useful in steep terrain. The structure rises on a steady curve until it has completed a loop, passing over itself as it gains elevation, allowing the vehicles to gain heights in a relatively short horizontal distance. (Refer to Figure 29).

This is a better alternative to zig-zag roads and avoids the need for vehicles to stop and reverse direction while ascending/descending. The shape of the structure does not form a spiral but a helix. Many multi-story car parking buildings feature such a design. The span range is medium to long.

Figure 29 Spiral Ramp to Nanpu Bridge in Shanghai, China

Box Girder Bridges

Overview

In these bridges, the main beams consist of hollow-box-shaped girders. The box girder is made of structural steel, prestressed concrete, or a composite of reinforced concrete and steel. (Refer to Figure 30). The span range is medium to long.

The box is usually trapezoidal or rectangular in cross-section. It reduces the slab thickness, weight of the bridge, as well as construction costs, while providing higher strength per unit area of concrete. Such bridges are mostly used for highway flyovers and modern elevated structures of light rail transport.

Figure 30 Open Trapezoidal Composite Box Girder during Construction

Segmental Bridges

Overview

Unlike conventional construction techniques that build structures in large sections, segmental bridges are constructed in small parts called segments (one piece is installed at a time). (Refer to Figure 31). The span range is long, over 100 meters.

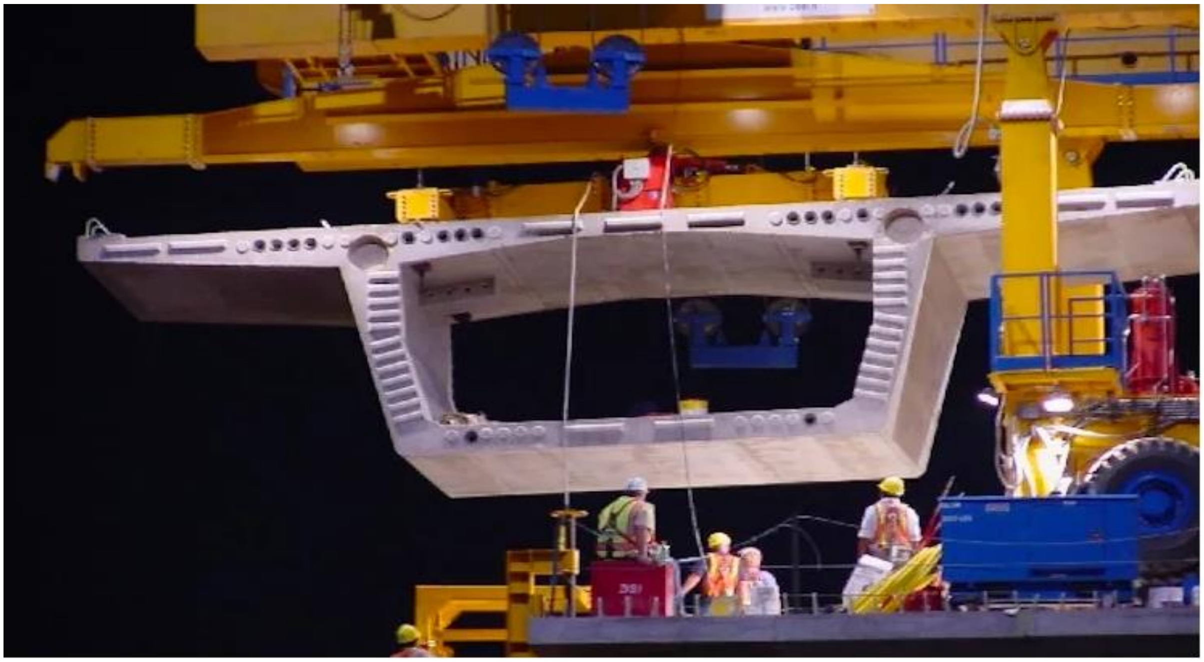

Figure 31 Construction of a Segmental Bridge on the 'Dallas High Five Interchange'

These bridges are made of concrete parts that are either built at another location and transported to the construction site or built fully at the final location. Although this type of design is very economical for long spans, it requires high-tech machines and a lot of safety precautions during construction.

Transporter Bridges

Overview

Transporter bridges carry a segment of roadway across a river. They have been used to cross navigable rivers or other water bodies, where there is a need for ship traffic to be able to pass (Refer to Figure 32). The span range is short.

Transporter bridges are rare type of bridges: fewer than 30 structures have been built so far. Of those, only twelve bridges are being used today. Middlesbrough Transporter Bridge, for example, is a 2,600-ton steel structure built across the River Tees, England. It provides a span of 570 feet to accommodate sailing ships.

Figure 32 Middlesbrough Transporter Bridge Built in 1911

Girder Bridges

Overview

As the name suggests, these bridges use girders made of either steel or concrete. Girder is the main horizontal support of the bridge that supports smaller beams on the deck. Most girders have an I-beam cross-section containing two load-bearing flanges separated by a stabilizing web (Refer to Figure 33). The span range is short to medium.

Figure 33 Multi-Span Plate Girder Bridge Deck on Concrete Piers

Girder bridges have come a long way from their limited short-span applications to cost-effective functional form, becoming one of the most widely used bridge types of this era.

Advances in material sciences and construction techniques continue to promote more widespread uses of such bridges in applications that were unheard of several decades ago.

Extradosed Bridges

Overview

The extradosed bridge combines the main elements of a cable-stayed bridge and prestressed box girder bridge. It uses smaller pylons than the cable-stayed bridge, and a significantly thinner girder/deck structure than used on the girder bridge (Refer to Figure 34). The span range is medium.

These bridges are relatively expensive and material inefficient. Almost any span that could be built by an extradosed bridge could be spanned more efficiently (with less material) with a cable-stayed bridge, or more inexpensively with a continuous girder bridge. However, they are used when overall navigation clearance, height, or aesthetic requirements make girder or cable-stayed alternatives less feasible.

Figure 34 Ganter Bridge in Switzerland

Trestle Bridges

Overview

A trestle bridge contains several short spans supported by closely-spaced frames. The trestle, which is used as bridge support, is a rigid frame made of either wood or iron (Refer to Figure 35). The span range is short.

Figure 35 Montana Trestle Bridge

Iron and timber trestles were widely used across the world in the 19^{th} century. In fact, timber bridges once accounted for up to 3% of the total length of the average railroad. Although these bridges are largely outdated, they are still invaluable to infrastructure systems. For example, steel or timber trestles are often built in areas where a filled-in bridge could block potential floodwaters.

Cantilever Spar Cable-Stayed Bridges

Overview

These types of bridges are modern variations of the cable-stayed bridges. In such bridges, the distribution of forces does not depend entirely on the cantilever action of the spar (supporting tower). The weight distribution in the spar and the angle of the spar away from the bridge play a significant role in reducing the overturning forces applied to the spar foundation (Refer to Figure 36). The span range is short to medium.

Figure 36 Assut de l'Or Bridge in Spain

In some bridges, the spar is titled up to an angle where it is counterbalanced by a structural tail. Many designs feature a curved backward spar to support the weight of the deck.

Side-Spar Cable-Stayed Bridges

Overview

This bridge is quite an uncommon bridge in which the cable support does not span the roadway; instead, it is cantilevered from one side. The cable paths are usually aligned with the centerline of the bridge (Refer to Figure 37).

The forces are transmitted through the cable stays (tension forces), then into the tower (compression forces), and then into the foundation. The span range is medium.

Such bridges would be suitable for regions where the road goes in the upstream direction, crosses a stream, and turns back on the other side in the downward direction. By building a portion of the turn on the structure, the turn can be made more gentle, allowing traffic to move faster.

Figure 37 Esplanade Riel in Manitoba

Section 6 — References

1. US Department of Transportation, Federal Highway Administration, Bridges and Structures.