1-1 History of Bridges

People have always been interested in transporting themselves and their goods from one place to another. So the rivers, mountains and valley are considered as a basic problem facing the people in their transportation and movement from one place to another. So in the beginning they thought to pass that obstruction and move away. First they used a rope or swimming and finally they reached to use a bridge that was mode of simple materials like rock, stone, timber and other materials was available at that time.

The history of development of bridge construction is closely linked with the history of human civilization. The first bridges were simple beam span of stone slabs or tree trunks, and for longer spans, single strands of bamboo or vine were stretched across the chasm or oops or baskets containing the traveler were pulled across the stretched rope.

The bridges in which timber cantilever beam extended out from piers on both sides of the stream where built in china. In 4000 B.C. arch structures have been found in Egypt. From the 9th century B.C. early Romans used the stone arch in bridges. In early history in Iraq, the Babylon's constructed a bridge near Ashtar across the Euphrates; the span of this bridge was about 130 meters. One of the ancient arches bridges in Iraq about 400 B.C. that had been discovered in Ur, in south of Iraq.

1-2 Importance of bridge

Bridges have always been an important part of our environment. They have been major subjects of literature and art, both – ancient and modern. Wars have been fought over bridges and in many cases the capture of strategic structure has had a pronounced effect on the final outcome of the war, bridges have been the center of village or city life. Today the structural engineer has at his disposal the most powerful analytical tool ever imagined, the digital computer; this instrument can perform in a matter of minutes a volume of calculations that would have previously taken years.

1-3 Definition

A bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may by a river, a road, railway or a valley.
1-4 Components of a bridge

The main parts of a bridge structure are as below:

- Decking, consisting of slab, girders, trusses, etc...
- Bearings for the decking.
- Abutments and piers.
- Foundations for the abutments and piers.
- River training works, like revetment for slopes at abutment, aprons at bed level, etc.
- Approaches to the bridge to connect the bridge proper to the roads on either side; and
- Handrails, guard stones, etc...

The component above the level of bearing are grouped as superstructure,
While, the parts below the bearing level are classified as substructure.

1-5 Classification

Bridge may be classified in many ways, as below:

- According to function as aqueduct (canal over a river), viaduct (road or railway over a valley), pedestrian, highway, railway, road-cum-rail or pipe line bridge.
- According to the material of construction of superstructure as timber, masonry, iron, steel, reinforced concrete, prestressed concrete, composite or Aluminum Bridge.
- According to the form or type of superstructure as slab, beam, truss, arch or suspension bridge.
- According to the inter span relations as simple, continuous or cantilever bridge.
- According to the position of the bridge floor relative to the superstructure, as deck, though, half-through or suspended bridge.
- According to the method of connections of the different parts of the superstructure, particularly for steel construction, as pin connection, riveted or welded bridge.
- According to the road level relative to the highest flood level of the river below, particularly for a highway bridge, as high-level or submersible bridge.
- According to the method of clearance for navigation as high-level, movable-bascule, movable-swing or transporter bridge.
- According to span length as culvert (less than 8m), Miner Bridge (8 to 30m), major bridge (above 30m) or long span bridge (above 120m).
- According to degree of redundancy as determinate or in determinate bridge.
- According to the anticipated type of service and duration of use as, permanent, temporary, military (pontoon, Bailey) bridge.
Bridge may be classified in many ways, as shown in figures:
Bridge designed to carry the following loads and forces:

2-1 Dead Load

Are these that are constant in magnitude and fixed in location through the life line of structure. And the load of a bridge consists of the weight of structure plus any equipment attached. Some bridge carry water or utility lines that may add appreciable weight; it is necessary to make a preliminary estimate of the dead load on which to base the initial design.

2-2 Live Load

Consist chiefly of occupancy loads in building and traffic loads on bridges. They may be either fully or partially in place or not present at all and may also change in location; there magnitude and distribution at any given time are in certain and even there max intensities throughout the life time of structure not known with precision.

2-3 Wind Load

All bridges structure should be designed to against the wind forces; there forces are considered to act horizontally and in a such a direction as to cause the maximum stresses in the member under consideration.

2-4 Centrifugal Forces

Where a road bridge is located on a curve, the effects of centrifugal forces due to movement of vehicles should be taken into account.

The centrifugal force is given by equation:

\[ C = \frac{WV^2}{127R} \]

Where:

C = centrifugal force in tons.
W = live load (1) in tones for wheel loads (2) in (ton/m) for uniformly distributed live load.
V = design speed in (Km/hr)
R = the radius of the curvature in (m)

2-5 Longitudinal forces
When a vehicle brakes or accelerates longitudinal forces are transmitted from its wheels to the deck of the bridge. The magnitude of the longitudinal forces depends on the amount of acceleration or deceleration. The maximum longitudinal force results from sudden braking of the vehicle, the magnitude of which is dependent on its weight, its velocity at the instant of braking, and the time it takes to come to a complete stop. This force is given by:

\[ F = \frac{w}{g} \left( \frac{\Delta v}{\Delta t} \right) \]

Where:

- \( W \) = weight of vehicle
- \( G \) = acceleration of gravity
- \( (\Delta v) \) = changing in velocity in the interval \( (\Delta t) \)

### 2-6 Impact Load

When the vehicle moving across a bridge, a normal rate of speed produces greater stress than if the vehicle is in static condition, and for the computing the dynamic effect the AASHTO specification gives the equation for determining the impact factor:

\[ I = \frac{15.24}{(L + 38)} \]
Arch bridges are one of the oldest types of bridges and have great natural strength. Instead of pushing straight down, the weight of an arch bridge is carried outward along the curve of the arch to the supports at each end. These supports, called the abutments, carry the load and keep the ends of the bridge from spreading out. When supporting its own weight and the weight of crossing traffic, every part of the arch is under compression. For this reason, arch bridges must be made of materials that are strong under compression.

Today materials like steel and pre-stressed concrete have made it possible to build longer and more elegant arches, including a spectacular 1700 foot span in New River Gorge, West Virginia. (More typically, modern arch bridges span between 200-800 feet.)

A beam or "girder" bridge is the simplest and most inexpensive kind of bridge. In its most basic form, a beam bridge consists of a horizontal beam that is supported at each end by piers. The weight of the beam pushes straight down on the piers.

The beam itself must be strong so that it doesn't bend under its own weight and the added weight of crossing traffic. When a load pushes down on the beam, the beam's top edge is pushed together (compression) while the bottom edge is stretched (tension). Pre-stressed concrete is an ideal material for beam bridge construction; the concrete withstands the forces of compression well and the steel rods imbedded within resist the forces of tension. Pre-stressed concrete also tends to be one of the least expensive materials in construction. But even the best materials can't compensate for the beam bridge's biggest limitation: its length.
The farther apart its supports, the weaker a beam bridge gets. As a result, beam bridges rarely span more than 250 feet. This doesn’t mean beam bridges aren’t used to cross great distances -- it only means that they must be daisy-chained together, creating what’s known in the bridge world as a "continuous span."

Cable-stayed bridges may look similar to suspensions bridges -- both have roadways that hang from cables and both have towers. But the two bridges support the load of the roadway in very different ways. The difference lies in how the cables are connected to the towers. In suspension bridges, the cables ride freely across the towers, transmitting the load to the anchorages at either end. In cable-stayed bridges, the cables are attached to the towers, which alone bear the load.

The cables can be attached to the roadway in a variety of ways. In a radial pattern, cables extend from several points on the road to a single point at the top of the tower. In a parallel pattern, cables are attached at different heights along the tower, running parallel to one other. For medium length spans (those between 500 and 2,800 feet), cable-stayed are fast becoming the bridge of choice. Compared to suspension bridges, cable-stayed require less cable, can be constructed out of identical pre-cast concrete sections, and are faster to build. The result is a cost-effective bridge that is undeniably beautiful.

Aesthetic, light and strong, suspension bridges can span distances from 2,000 to 7,000 feet -- far longer than any other kind of bridge. They also tend to be the most expensive to build. True to its name, a suspension bridge suspends the roadway from huge main cables, which extend from one end of the bridge to the other. These cables rest on top of high towers and are secured at each end by anchorages.
The towers enable the main cables to be draped over long distances. Most of the weight of the bridge is carried by the cables to the anchorages, which are imbedded in either solid rock or massive concrete blocks. Inside the anchorages, the cables are spread over a large area to evenly distribute the load and to prevent the cables from breaking free.

3.5 Girder Bridge

A girder bridge is perhaps the most common and most basic bridge. A log across a creek is an example of a girder bridge in its simplest form. In modern steel girder bridges, the two most common girders are I-beam girders and box-girders.

An I-beam is very simple to design and build and works very well in most cases. However, if the bridge contains any curves, the beams become subject to twisting forces, also known as torque. The added second web in a box girder adds stability and increases resistance to twisting forces. This makes the box girder the ideal choice for bridges with any significant curve in them.

Box girders, being more stable are also able to span greater distances and are often used for longer spans, where I-beams would not be sufficiently strong or stable. However, the design and fabrication of box girders is more difficult than that of I-beam.

3.6 Truss

The truss is a simple skeletal structure. In design theory, the individual members of a simple truss are only subject to tension and compression
Forces and not bending forces. Thus, for the most part, all beams in a truss bridge are straight. Trusses are comprised of many small beams that together can support a large amount of weight and span great distances. In most cases the design, fabrication, and erection of trusses is relatively simple. However, once assembled trusses take up a greater amount of space and, in more complex structures, can serve as a distraction to drivers.

**Illustration #1** Like the girder bridges, there are both simple and continuous trusses. The small size of individual parts of a truss makes it the ideal bridge for places where large parts or sections cannot be shipped or where large cranes and heavy equipment cannot be used during erection. Because the truss is a hollow skeletal structure, the roadway may pass over (illustration #2) or even through (illustration #1) the structure allowing for clearance below the bridge often not possible with other bridge types.

**Illustration #2** Trusses are also classified by the basic design used. The most representative trusses are the Warren truss, the Pratt truss, and the Howe truss. The Warren truss is perhaps the most common truss for both simple and continuous trusses. For smaller spans, no vertical members are used lending the structure a simple look (illustration #1.) For longer spans vertical members are added providing extra strength (illustration #2.) Warren trusses are typically used in spans of between 50-100m.

**Illustration #3** The Pratt truss (illustration #3) is identified by its diagonal members which, except for the very end ones, all slant down and in toward the center of the span. Except for those diagonal members near the center, all the diagonal members are subject to tension forces only while the shorter vertical members handle the compressive forces. This allows for thinner diagonal members resulting in a more economic design.
Most highway bridges in the United States are designed according to requirements of the American Association of State Highway and Transportation Officials (AASHTO specification). Its specifications contain provisions governing loads and load distributions as well as detailed provisions relating to design and construction.

**The duck slab**

1.1 Min thickness
1.2 Load
1.3 Span length
1.4 Moments
   1.4.1 Dead load moment
   1.4.2 Live load moment
   1.4.3 Impact moment
1.5 Design
   1.5.1 Check for flexure
   1.5.2 Check for shear
1.6 Reinforcement
   1.6.1 Main reinforcement
   1.6.2 Longitudinal reinf.
   1.6.3 tem.& shrinkage reinf.

**Girder**

2.1 Number of girder
2.2 Internal girder
   2.2.1 load and moment
      2.2.1.1 dead load moment
      2.2.1.1 live load moment
   2.2.2 shear
3.2.1 live load shear

3.2.2 dead load shear

2.3 external girder

2.4 design

2.4.1 for moment

2.4.2 for shear

2.5 Serviceability Requirements

2.5.1 control of crack

2.5.2 control of deflection bearing plate

**Bearing plate**

3.1 loads

3.1.1 dead load

3.1.2 Live load

3.2 design

3.2.1 Initial design inputs

3.2.2 Bearing geometry

3.2.3 Shear deformation

3.2.4 Compressive stress

3.2.5 Combined compression and rotation

3.2.6 Reinforcement

**Design of substructure**

4.1 Analysis and design pile

4.1.1 Load on pile

4.1.2 Design the pile

4.1.2.1 Mean reinforcement

4.1.2.2 The spiral reinforcement
4.2 Pile cap reinforcement

4.2.1 Flexural design

4.2.2 Shear design

Reference


2) From net by Google "types of bridge."

3) Bridges and constructions on roads (Dr. Sadek Sinan).