CONSTRUCTION

An early history of bridge building

The Romans' legacy to bridge building was the heavy masonry arch bridge, hundreds of which were built throughout Europe. In this, large stone blocks were wedged against each other to form an arch. The central stone at the top of the arch was known as the keystone. The finest surviving example of such a bridge is the Pons Fabricius in Rome. Completed in 62 BC, the bridge (now called the Ponte de Quattro Capi) has two fine semicircular arches each spanning 78 feet. A small "relief" arch in the central sponging of the two main arches releases excess water in times of flood.
So prolific and efficient was Roman building that it was hundreds of years before Europeans took to bridge building anew. Then, in the 12th century Catholic priests and professionals took over the building of bridges because the Church recognized the advantages of good road communications in a developing society.

The Ponte de Quattro Capi

In France a group of interested priests formed a new order, the Freres du Pont, to design and build lasting bridges. Most famous of this order’s works was the Pont d’Avignon, built in 1177 over the Rhone River. It had 21 arches in all, the longest spanned 115 feet. Similarly in England it was Peter de Colechurch who designed and built the first stone bridge over the Thames, the famous London Bridge. Another was done by the architect-priest Giovanni Giocondo (1433-1515) who used the segmental arch in Paris’ first masonry bridge, built in 1507.
Until the late 17th century bridges continued to be designed and built largely by priests or architects with a flair for engineering. But such complex and essential work could not rest in the hands of gifted amateurs forever. In 1716 French army engineers took the lead on the rest of the world in bridge building.

### Meaning of Bridge

- a structure that allows people or vehicles to cross an obstacle such as a river or canal or railway etc.
- connect or reduce the distance between.
Requirements

- Bridges are structures used by people and vehicles to make crossing areas easier in travel.
- Engineers build bridges over rivers, lakes, ravines, canyons, railroads, and highways.
- Bridges must be built strong enough to safely support their own weight as well as the weight of the people and vehicles that pass over it.
- The bridge must also withstand natural occurrences that include weathering, earthquakes, strong winds, and freezing and thawing.
- Often when designing structures, there are two very important requirements:
  - to carry the most weight possible,
  - to be as light as possible.

Evaluation

- meets construction requirements
- most efficient
- most weight held
- most unique bridge designs
- aesthetic appeal and craftsmanship
- highest quality bridge drawings (3D-view)
Weight of Structure

1. An increasing load will be applied to the bridge until the bridge fails.
2. The load will be weighed and entered in the formula as "Failure Weight."
3. The bridge will be weighed before testing and the weight entered into the formula as "Weight of Structure."
4. The bridges with the highest number will get the most points for efficiency.

The Holtekamp Bridge

Materials for Bridges

- The most common materials used for today’s bridges are steel and concrete. Most bridges have some of both. Steel bridges usually have concrete roadways. Concrete bridges are usually reinforced with steel.
- Concrete is strong in compression. That makes it a good choice for columns and arches. However, concrete is weak in tension. If concrete is used for beams, it must be reinforced with steel, which has good tensile strength. This is done by placing steel bars (called "rebar") in the concrete in locations where there is likely to be tension. For example, for a cantilever beam, the bar would be placed near the top. That is the area where tension will develop. The steel bars can be hardened before the concrete has hardened or they can be glued into pre-formed tunnels within hardened concrete.
Materials for Bridges (cont’d.)

- Prestressed concrete is another type of reinforced concrete. It is made by stretching the steel reinforcing bars before they are placed in the concrete. Once inside the concrete, the bars try to return to their original size, but the concrete prevents them from doing this. The resulting stress will counteract the tension the concrete will be subjected to in use.
- Steel resists both tension and compression. It is also lighter than concrete, but it costs more. For short spans, concrete may be the better choice. Long spans, however, would require so much concrete that the bridge would become extremely heavy. To reduce the amount of dead load, steel is used instead. That’s why very long bridges are mainly steel. The cables that support the roadway are very high in tensile strength. In the Humber Bridge, for example, each of the wires in the cables can withstand a tension of 3 tons. There are 14,948 wires in each cable.

How Bridges are Planned

- The bridges in your community were built to meet a need.
- They make it possible for people and goods to move from one area to another.
- In planning a new bridge, the first step is to prove that the bridge is needed. Perhaps a new highway is being built, and bridges are needed to cross it. Perhaps an old bridge over a river needs to be replaced. Because bridges are very expensive to build, the bridge must be shown to be worth its cost.
How Bridges are Planned (cont’d.)

- The government with taxpayers’ money usually pays the cost of the bridge. Often, a combination of city, state, and federal funds are used. Have you ever been on a toll bridge? The toll is the money that drivers pay for crossing the bridge. These tolls help to pay the cost of building and maintaining the bridge.

- Any kind of construction will have an effect on the plants, animals, and people living in the area. Before most bridges can be built, studies must be done to determine their impact on society and the environment.

How Bridges are Designed

PURPOSE

- One of the first things to think about is the purpose of the bridge. Of course, the purpose of any bridge is to help travelers get from here to there. Will the bridge cross a river or highway? Will it be used by cars, by trains, or by people traveling on foot? A basic rule of design is that form follows function. In other words, the design of the bridge is determined by its purpose.
How Bridges are Designed (cont’d.)

SITE

✓ Engineers must also consider the site (location). For example, suppose the bridge is to be built across a river. A beam bridge is fairly simple to construct. However, its span length is limited to about 700 feet (210 meters). If the river is wide, multiple spans supported by piers will be needed. Perhaps a cantilever bridge would be better. It would require fewer piers than the Beam Bridge. If a river were very wide, a suspension bridge would be the best choice. Suspension bridges can carry the longest spans.

✓ The land around the bridge must be carefully checked. Are there hills or valleys that will make construction more complicated? Are there sewer pipes or power lines on the construction site? Will people crossing the bridge have to cross streams or railroad tracks?

Process to Build the Bridge

a. The site is reviewed to determine the readiness of footing or abutment.

b. If necessary, an abutment is pile driven (1 day of work and you are ready to install) or cement is poured (cure time is roughly 2 weeks).
c. The crew, using a loader, excavator, crane or other equipment, off loads the Bridge.

d. Beams are placed and secured on abutment.

e. Modules are slid in place between beams.

f. Bolts are tightened and checked.
Process to Build the Bridge (cont’d.)

h. Handrails, or other options, are attached.

i. Deck joints are sealed.

Process to Build the Bridge (cont’d.)

j. The grade, or road approach, is completed.

k. The finished bridge is both attractive and functional.
Foundation

"A quality foundation can triple the life of your bridge..."

Type of Foundation

Steel Pile
The cheapest and fastest abutment solution, Steel Pile only has one drawback. The soil must be soft for a pile driver to work. A Pile driver inserts I-beams down into the earth, giving the bridge a solid footing. Unfortunately, if the soil makeup is primarily rock, this methodology is impossible.
Modular Blocks
This new technology utilizes custom 2000 pound cement blocks that interlock, giving you an attractive, durable abutment. These same blocks are used very reliably for retaining walls. There are a variety of options available and can be customized to your particular need.

Concrete Foundation
While a good choice, you can expect greater prices, and longer installation times. A form is created, re-bar adds strength, and cement is poured. Expect 2 weeks cure time, and you are ready to install!
The 4 Key Roles in the Design and Construction Process

1. **Owner**: a person or organization that initiates the project.
2. **Design Professional**: is responsible for conceiving, planning and providing high quality designs to owner.
3. **Constructor**: is responsible for planning, managing and constructing the structure after it has been designed. This is where the engineers come in.
4. **Project Manager**: is responsible for managing both the design and construction looks after the owner’s interests.

Construction Quality

- Any construction error can cause the structure to fail causing major problems, such as: accidents, injuries, and collapse.
- In the case that it doesn’t fail or collapse, the appearance of the structure may be off causing it to look sloppy (careless).

Thanks for your attention and success with your study!