

History of Civil Engineering and Architecture

Concepts

1. Many features of ancient structures are seen in modern buildings.
2. Architectural style is often an important key to understanding how a community or neighborhood has developed and the aesthetic customs that have formed over time.
3. The multiple architectural styles that have been developed throughout history are an indication of changing needs of people and society and uses for space.
4. Visual design principles and elements constitute an aesthetic vocabulary that can be used to describe buildings and may help identify the buildings function, location, or time period.

Civil engineering and architectural history are unique because a great deal of historical evidence exists. Monuments, buildings, and evidence of such are located all over the world. Since shelter is a basic human need, building these types structures occur in all cultures, eras, and places.

These historical structures also challenge modern perceptions of the knowledge, tools, and skills that ancient engineers possessed. The accomplishments of ancient builders and engineers amaze modern thinkers with their scope, accuracy, size, etc. The Egyptian pyramids are not only large, but they are level. Each corner is aligned with polar coordinates. Erecting the rocks for Stonehenge would seemingly require large, modern equipment. Often these accomplishments seem so impossible that they lead to fanciful explanation such as alien involvement. Historical examples of amazing construction projects often lead to the realization that the ancients' construction methods were not so different from modern methods and sometimes much more clever.

In this lesson students will learn about the history of civil engineering and architecture. They will begin to build a vocabulary around both, including the principles and elements of design and architectural styles.

- Civil engineering is the oldest branch of engineering. Not only do civil engineers design systems that interact with one another, but they are also concerned with the environment's well-being. The term "civil" was added to separate these licensed professionals from other engineers who worked on military, electrical, or mechanical projects.
- Architects are licensed professionals who design commercial and residential structures that are used by humans.
- Architecture was born when people began to live in constructed dwellings and within communities. Caves were last used as habitats around 8000 BC.
- Early engineering was centered around food. The development of tools and ways to increase the efficiency of farming and hunting were documented, first in cave paintings and later in Egypt with hieroglyphics.
- The history of civil engineering and architectural projects is regional in nature. The development of building design and construction on an African grassland differs greatly from building design and construction in Alaska or the mountainous regions of Peru. A major reason for differences in the development of construction techniques is the availability of local materials. Although it is possible to import materials from great distances, the historic reality is that people often used what was easily available to them when constructing buildings. This influenced architectural style and the selection of structural elements. Of course climate also has an effect on the design and construction of buildings. For example, sun dried bricks can support loads in a dry climate but will disintegrate in wet climates.
- Current day Iraq consists mostly of alluvial plains – no stone, and wood is scarce. Sun-dried bricks (clay-rich soil mixed with straw) was used as early as the 4th millennium BC. The ruins of the famed city of Babylon illustrate the use of mud-bricks.
- Greece consists almost entirely of limestone and has many sources of marble. The finest source of marble is Mount Pentelicus from which the marble used in the Parthenon was cut.
- The pre-Columbian Inca site of Machu Picchu sits on a mountain ridge in Peru. The central buildings of Machu Picchu use the classic architectural style of dry stone walls in which blocks of stone are cut to fit together tightly without mortar.
- Because of their durability, examples of stone and brick buildings from past civilizations do exist. However, few examples of ancient buildings exist where less durable materials such as wood and grass were used.
- In China and in Japan, most ancient buildings were constructed of wood (except for the tile roofs). Because wood tends to deteriorate over time, few examples of ancient Chinese buildings exist. However, the Chinese have long standardized uniform features of structures through manuals and drawings that were passed down for generations. Therefore, we can determine that Chinese architecture changed little over thousands of years.
- **Vernacular architecture** is a term used to categorize methods of construction which use locally available resources and traditions to address local needs. It is often viewed as crude and unrefined, but many modern architects have claimed inspiration from vernacular architecture
- The earliest large structures were the pyramids. Pyramids in Egypt were built as monuments to house the tombs of the pharaohs.
- The earliest known architect was Imhotep (/m HO tep) of Egypt. He was known for creating the first step pyramid at Sakkara (suh CAH ruh) around 2700 B.C. This pyramid was a solid structure, but many early buildings were bearing wall types. **Bearing walls** are solid walls that provide support for each other and for the roof. The building next to the pyramid in the right image illustrates a bearing wall system.
- 200 years later, the Great Pyramid of Khufu (KOO foo) was built. It is the largest masonry structure ever built. The base measures 756 ft on each side and is 480 ft tall. The builder was Cheops (KEE ops), also known as Khufu. His pyramid is the only surviving of the Seven Wonders of the Ancient World.
- **Aesthetics** is the quality of an object that deals with art, beauty, and taste.
- Supporting large openings was a major problem in the early design of structures. Although very strong in compression, stone is weak in tension and cannot support the weight of the structure across a large openings. The Romans developed the **arch** to overcome the limitations of the post and lintel. An arch is a curved structure for spanning an opening, designed to support a vertical load primarily by axial compression. Because they are made from smaller and lighter blocks of stone, they are easier to erect. Blocks are placed in a curved formation in such a way that they give each other support. The wedge-shaped units in the arch are called **vousoir** (voo SWAR). The **keystone** is the vousoir at the crown of the arch, serving to lock the others in place.
- The arch is often used in the construction of bridges, tunnels, sewers, and palaces.
- The development of the arch led to the **vault**, which is a series of arches that form a continuous arched covering.

- When two of these vaults intersect, a **cross vault** is created. Another name for the cross vault is the groin vault. Vaults allow for the construction of bridges, walkways, and other passages.
- A **dome** is an arrangement of several arches whose bases form a circle and the tops meet in the center.
- The Pantheon is an example of an arch and dome system. It is the oldest standing domed structure in Rome.
- Two amazing aspects of the Pantheon have to do with the materials used to create it.
- The Pantheon's concrete was a mixture of volcanic ash, lime, and a small amount of water. That mixture was packed, not poured, into place. Today we have **Portland cement**, a hydraulic cement that is a key ingredient in concrete and many other cementitious (SEE men TISH us) products such as masonry bricks and plaster. Hydraulic cement hardens by reacting with water and is water-resistant.
- Ancient roadways were used by the Persians and Romans for strategic and commercial purposes.
- Greeks needed to have roads available in the event of a religious exodus. Greek highways consisted of two wheel ruts of about 4 ft 11 in. gauge either carved out or worn down. The roads typically had a width of 8 or 9 feet and a depth of 3 to 4 inches. Sometimes this was increased to 12 inches to make the road smoother in the rocky ground. Urban streets were mostly paved.
- Roman roads were created by using large blocks of stone (called the stratumen) for the base, over which broken stone or debris (called rudus) was spread and covered by a layer of sand (referred to as the nucleus) and finally by large polygonal basalt blocks (sumum dorsum), with the polished top surfaces serving as the road surface. The stones were set in lime mortar. In marshy regions the Romans used wooden causeways resting on pile foundations.
- The earliest know Roman bridge, the Pons Sublicius in Rome, was made of wood and was constructed using columns and beams. The pile foundation was created by following specific steps: excavate, clear, and then drive previously charred alder, olive, or oak piles into the ground as close to each other as possible. The spaces were filled with ashes.
- The Eiffel tower, as one of the last iron structures, marked the end of the iron era. In the 1890s steel replaced iron as the material of choice for large construction projects. Although it contains iron, steel also contains carbon which makes the metal harder and tougher. In addition, steel is less susceptible to corrosion. Steel frames were designed to carry the building loads so that massive load bearing walls were no longer necessary. The heights of buildings grew
- The concrete mixture used by the Romans was very weak in tension and bending. Experiments with improving the tensile strength of concrete by embedding metal rods into the mixture began in the mid 1800s. Eventually engineers learned how to efficiently take advantage of the combined strength of concrete in compression and steel in tension. Since that time, reinforced concrete has been used for a variety of construction projects. The flexibility of concrete allowed the use of free flowing curves and a break from the rectilinear designs of structural steel.
- Engineers quickly understood that reinforced concrete could be used in the design and construction of bridges. The first reinforced concrete bridge was built in France in 1907.

Connect modern structural and architectural designs to historical architectural and civil engineering achievements.

- Identify three general categories of structural systems used in historical buildings.
- Explain how historical innovations have contributed to the evolution of civil engineering and architecture.
- Identify and explain the application of principles and elements of design to architectural buildings.
- Determine architectural style through identification of building features, components, and materials

Visual Design Elements

Six integral components used in the creation of a design:

Line	Space
Color	Texture
Form and Shape	Value

Form and Shape

Form: (3D)The shape and structure of something as distinguished from its substance or material.

Shape: (2D)The two-dimensional contour that characterizes an object or area.

Visual Design Principles

Seven principles encompass an interesting design.

- Balance
- Rhythm
- Emphasis
- Proportion and scale
- Movement
- Contrast
- Unity

Study excel chart for the Architectural Styles