Civil Engineering: The Past, Present, and Future

What is Civil Engineering?

Civil Engineering: The Past
- Engineering has developed from observations of the ways natural and constructed systems react and from the development of empirical equations that provide bases for design.
- Civil engineering is the broadest of the engineering fields.
- In fact, engineering was once divided into only two fields -- military and civil.
- Civil engineering is still an umbrella field comprised of many related specialties.

Civil Engineering: The Present
- In modern usage, civil engineering is a broad field of engineering that deals with the planning, construction, and maintenance of fixed structures, or public works, as they are related to earth, water, or civilization and their processes.
- Most civil engineering today deals with infrastructure: such as; power plants, bridges, roads, railways, structures, water supply, irrigation, environment, sewer, flood control and traffic.

The first self-proclaimed civil engineer was John Smeaton (1724 - 1792).

In 1818 the Institution of Civil Engineers was founded in London and received a Royal Charter in 1828, formally recognizing civil engineering as a profession.

The first degrees in Civil Engineering in the United States was awarded to William Clement, Jacob Eddy, Edward Suffern and Amos Westcott by Rensselaer Polytechnic Institute in 1835.

The first such degree to be awarded to a woman was granted by Cornell University to Nora Stanton Blatch in 1905.
What is Civil Engineering?

Civil Engineering: The Present

- In essence, civil engineering may be regarded as the profession that makes the world a more agreeable place in which to live.
- Civil engineering is about community service, development, and improvement.
- [http://www.asce.org](http://www.asce.org)

What is Civil Engineering?

MemFix 4 – Replacement of four bridges along I-240

https://youtu.be/k5wL11WLJ5Y

What is Civil Engineering?

Falkirk Wheel – in town of Falkirk in central Scotland


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https://youtu.be/ucg1O-5jsnM
What is Civil Engineering?

Civil Engineering: The Future

- Our future as a nation will be closely tied to space, energy, the environment, and our ability to interact with and compete in the global economy.
- As the technology revolution expands, as the world's population increases, and as environmental concerns mount, your skills will be needed.
- Whatever area you choose, design, construction, research, teaching, or management, civil engineering offers you a wide range of career choices.

ASCE estimates that $3.6 trillion is needed by 2020 to bring the nation’s infrastructure to a good condition.
- Establishing a long-term development and maintenance plan must become a national priority.
- But in the short term, small steps can be taken by the Congress, as well as state legislatures and local communities, to improve our nation's failing infrastructure.

See ASCE website: http://www.infrastructurereportcard.org

What is Civil Engineering?

Civil Engineering: The Future

The I-35W Mississippi River bridge was an eight-lane, 1,907 feet (581 m) steel truss bridge that carried Interstate 35W across the Mississippi River in Minneapolis, Minnesota, United States.

At 6:05 p.m. CDT on Wednesday, August 1, 2007, with rush hour bridge traffic moving slowly through the limited number of lanes, the central span of the bridge suddenly gave way, followed by the adjoining spans.

The primary cause was the under-sized gusset plates, at 0.5 inches (13 mm) thick. Contributing to that design or construction error was the fact that 2 inches (51 mm) of concrete were added to the road surface over the years, increasing the dead load by 20%.
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What is Civil Engineering?
Old photos of the Interstate 35W bridge show that two steel connecting plates were slightly bent as early as 2003 - four years before the span collapsed into the Mississippi River, killing 13 people.

What is Civil Engineering?
What about Tennessee’s infrastructure?
- 38% of Tennessee’s major urban roads are congested.
- Driving on roads in need of repair costs Tennessee motorists $899 million a year in extra vehicle repairs and operating costs – $182 per motorist.
- Congestion in the Memphis area costs commuters $547 per person per year in excess fuel and lost time.
- Tennessee’s gas tax of 21.4 cents per gallon has not been increased in 23 years.

What is Civil Engineering?
What about Tennessee’s infrastructure?
- 17% of Tennessee’s bridges are structurally deficient or functionally obsolete.
- Tennessee’s drinking water infrastructure need is $3.5 billion over the next 20 years.
- Tennessee has $1.4 billion in wastewater infrastructure needs.
- Tennessee generates 1.27 tons of solid waste per capita.
- Tennessee recycles 26.4% of the state’s solid waste.

What is Civil Engineering?
Civil Engineering: Technical Specialties
- Construction Engineering
- Environmental Engineering
- Geotechnical Engineering
- Structural Engineering
- Transportation Engineering
- Urban Planning
- Water Resources

What is Civil Engineering?
Construction Engineering
- The construction phase of a project represents the first tangible result of a design.
- Using your technical and management skills, you will help turn designs into reality -- on time and within budget.
- You will apply your knowledge of construction methods and equipment, along with principles of financing, planning, and managing, to turn the designs of other engineers into successful facilities.
What is Civil Engineering?

Environmental Engineering
- Environmental engineers translate physical, chemical, and biological processes into systems to remove pollutants from water, reduce non-hazardous solid waste volumes, eliminate contaminants from the air, and develop groundwater supplies.
- In this field, you might be called upon to resolve problems of providing safe drinking water, cleaning up sites contaminated with hazardous materials, cleaning up and preventing air pollution, treating wastewater, and managing solid wastes.

Geotechnical Engineering
- Almost all of the facilities that make up our infrastructure are in, on, or with earth materials, and geotechnical engineering is the discipline that deals with applications of technology to solve these problems.
- Examples of facilities in the earth are tunnels, deep foundations, and pipelines. Highway pavements and many buildings are supported on the earth.

Structural Engineering
- As a structural engineer, you will face the challenge of analyzing and designing structures to ensure that they safely perform their purpose.
- They must support their own weight and resist dynamic environmental loads such as hurricanes, earthquakes, blizzards, and floods.
- Stadiums, arenas, skyscrapers, offshore oil structures, space platforms, amusement park rides, bridges, office buildings, and homes are a few of the many types of projects in which structural engineers are involved.

Transportation Engineering
- Because the quality of a community is directly related to the quality of its transportation system, your function as a transportation engineer will be to move people, goods, and materials safely and efficiently.
- You will design, construct, and maintain all types of facilities, including highways, railroads, airfields, and ports.

Water Resources
- Water is essential to our lives, and as a water resources engineer, you will deal with issues concerning the quality and quantity of water.
- You will work to prevent floods, to supply water for cities, industry and irrigation, to treat wastewater, to protect beaches, or to manage and redirect rivers.

Urban Planning
- As a professional in this area, you will be concerned with the full development of a community.
- Analyzing a variety of information will help you coordinate projects, such as projecting street patterns, identifying park and recreation areas, and determining areas for industrial and residential growth.
**What is Civil Engineering?**

ASCE’s members ranked the 10 greatest civil engineering achievements as:

1. Airport design and development
2. Dams
3. Interstate highway
4. Long-span bridges
5. Rail transportation
6. Sanitary landfills/solid waste disposal
7. Skyscrapers
8. Wastewater treatment
9. Water supply and distribution
10. Water transportation

**Airport Design**

- Before 1945, any level field was looked upon as a viable landing strip for airplanes, and it was generally believed that the presence of a gas pump made an airport ready for commercial traffic.

- After World War II, the advent of integrated, engineered systems of paved landing surfaces, floodlit runways, and terminal complexes made passenger convenience, airline efficiency, economy in construction and operational safety the cornerstones for the rehabilitation and development of airports worldwide.

**Kansai International Airport**

Located in Osaka Bay, approximately three miles off shore, Kansai International Airport features an extensive variety of modern amenities.

- **Start of the airport island seawall construction** (January 1987)
- **Completion of the airport island seawall** (June 1989)
- **Completion of the Passenger Terminal Building** (June 1994)

The airport serves 24 cities in Japan with 69 departures daily and 71 cities in 30 other countries with 660 departures.
During the 20th century, harnessing water by building dams was recognized as a way to meet an unprecedented demand for low-cost, widely available energy sources to aid in the production of goods and services for the consuming public.

Dams continue to play an integral role in our daily lives, providing a range of benefits including flood control, hydroelectric power, and water for irrigation, recreation, and fish and wildlife enhancements.

Dams spur industrial growth and provide navigation routes in developing nations. As the world’s population increases and the need for food multiplies, it is likely, even in the face of increased environmental sensitivity, which dams will continue to be built during the 21st century.

Completed in 1935, the 726-foot-high structure was the highest dam in the world, by 300 feet, at the time of construction. It is still the highest concrete dam in the Western Hemisphere.

Today, it continues to regulate the flow of the Colorado River and provides a range of benefits, including electricity for more than 1.3 million people and irrigation for 1.5 million acres of land in the United States and Mexico.
The building of the Three Gorges Dam is modern China's most ambitious construction project, and one of the most controversial in the world. It is also China's largest construction project since the building of the Grand Canal in the 10th century. From start to finish, the project will cost up to $29 billion.

The dam wall is made of concrete and is about 2,309 meters (7,575 ft) long, and 101 meters (331 ft) high. The wall is 115 meters (377.3 ft) thick on the bottom and 40 meters (131.2 ft) thick on top.

The project used 27,200,000 m³ (35,600,000 yd³) of concrete, 463,000 tons of steel, enough to build 63 Eiffel Towers, and moved about 102,600,000 m³ (1.342x10⁸ yd³) of earth.

The Interstate Highway System, first established as a national priority by President Dwight D. Eisenhower in the Federal-Aid Highway Act of 1956. The highway system revolutionized travel, economies and the daily standard of living in North America by providing an efficient means of direct, high-speed transportation for individuals and businesses in the United States, Canada and Mexico. The 48,181-mile system (as of 2016), built on a North-South/East-West grid, has hundreds of bridges, overpasses, interchanges and thousands of miles of pavement. The Interstate Highway System is both the largest highway system in the world and the largest public works project in history.
The system carries nearly 25% of all vehicle miles in the U.S. and is credited with saving more than 187,000 lives and preventing 12 million injuries. It is estimated that the Interstate Highway System saved $6 for every $1 spent on its construction.

Memphis

Bridges of increasing size and span have created phenomenal changes in the social patterns and economic conditions of areas by effectively eliminating water barriers between communities. They open new routes of communication between disintegrated and isolated communities, provide safe and efficient access to work, schools and recreation for people, and spur economic growth by facilitating trade within and between regions.

From the late 19th century through the early 20th century the use of steel enabled the production of increasingly longer, continuous main span traversing large, deep bodies of water.

Golden Gate Bridge

One of the most recognized landmarks in the world, the Golden Gate Bridge, connects geographically isolated areas of California to the north, in Marin and Sonoma counties, with San Francisco.

When the bridge opened in 1937, with a main suspension span length of 4,200 feet, it was the longest in the world.
Long-Span Bridges

Golden Gate Bridge
The engineering obstacles posed by the mile-wide, turbulent Golden Gate Strait led engineers to devise a bridge that required four years to build, 83,000 tons of steel, 389,000 cubic yards of concrete, and enough cable to encircle the earth three times.

Akashi Kaikyo Bridge
The Akashi Kaikyo Bridge, linking the islands of Honshu and Shikoku. The bridge’s center section stretches a staggering 6,529 feet. To keep the structure stable, engineers have added pendulum-like devices on the towers to keep them from swaying and a stabilizing fin beneath the center deck to resist typhoon-strength winds.

Rail Transportation

Eurotunnel Rail System
The Eurotunnel Rail System fulfilled a centuries-old dream to link Britain and the rest of Europe. More than a tunnel, it rolls infrastructure and immense machinery into an underwater tunnel system of unprecedented ambition.
Three five-feet-thick concrete tubes plunge into the earth at Coquelles, France, and burrow through the chalky basement of the English Channel, re-emerging at Folkstone, behind the white cliffs of Dover.

The broadest trains ever built (14 feet wide double deckers) travel through the tunnels at 100 mph. Passengers board in automobiles and buses, not on foot.

As American society changed from an agrarian culture to an industrialized nation, people moved to cities for work, in hopes of improving their quality of life.

The subsequent increase in urban population density had a great impact on garbage disposal practices.

By 1946, the responsibility for garbage disposal shifted from scavengers to scientifically minded civil engineers whose experimentation with various ways to properly dispose of waste which led to the widespread use of sanitary landfills.

Americans generate trash at an astonishing rate of about 4 pounds per day per person, which translates to over 250 million tons per year!

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Some trash gets recycled or recovered and some is burned, but the majority is buried in landfills.

Sanitary Landfills/Solid Waste Disposal

A landfill's major purpose and one of its biggest challenges is to contain the trash so that the trash doesn't cause problems in the environment. The bottom liner prevents the trash from coming in contact with the outside soil, particularly the groundwater.

Sanitary Landfills/Solid Waste Disposal

The Fresh Kills Landfill on Staten Island is set to officially close on July 4, 2001 after more than 50 years in operation.

Sanitary Landfills/Solid Waste Disposal

It consists of four mounds which range in height from 90 to approximately 225 feet and hold about 150 million tons of solid waste. The archaeologist Martin Jones characterizes it as "among the largest man-made structures in the history of the world."

Sanitary Landfills/Solid Waste Disposal

New York’s New Parkland at Fresh Kills will be one of the most ambitious public works projects in the world.

Skyscrapers

- Nineteenth century buildings generally did not exceed 16 stories in height because the strength and thickness of their mandatory bearing walls limited them.
- Built upward, instead of outward, skyscrapers of the 20th century have solved many of the problems of rapid urbanization, including increasing population and land cost.
- Tall buildings were made possible by such innovations as the electric elevator, advances in structural steel making, and advances in heating, ventilation, air conditioning and electrical systems.
At 1,250 feet, the Empire State Building is the best-known skyscraper in the world, and was the tallest building in the world for more than 40 years. The building's most astonishing feat, however, was the speed at which it rose into the New York skyline.

- Construction was completed in only one year and 45 days, without requiring overtime.
- Ironworkers set a torrid pace, riveting the 58,000-ton frame together in 23 weeks.
- Just below them, masons finished the exterior in eight months, plumbers laid 51 miles of pipe and electricians installed 17 million feet of telephone wire.
- The building was so well engineered that it was easily repaired after a bomber crashed into it in 1945.

Tallest structure in the World?
- Freestanding structure
- Freestanding structure on land
- Building – to top of antenna
- Building – to highest point
- Building – to architectural top
- Building – to top of roof
- Building – to highest occupied floor

- 2,722 feet high

Tallest Building in the World Under Construction
- Azerbaijan Tower (2030) - 3,458 ft.
- Jeddah Tower (2020) - 3,281 ft.
Throughout the 19th century people lived in filth, disposing of garbage and raw sewage by dumping it into streets, alleys and waterways. As a result, they often suffered from such deadly diseases as cholera and typhus. Until the early 1900s, America's urban wastewater, including industrial waste, was dumped into the nation's waterways. As recently as 1968, the city of St. Louis discharged 300 million gallons per day of raw waste into the Mississippi River. By 1972, only one-third of U.S. waterways were safe for drinking and fishing. With the advent of wastewater treatment, cities became much more equipped to deal with population influx.

The reversal of the Chicago River, completed in 1900, enabled Chicago to continue its growth and progress after the Great Chicago Fire of 1871. Before the reversal, the safety of the Lake Michigan drinking water supply was constantly threatened by untreated sewage flowing directly into the river, which then flowed back into the lake. The Chicago Sanitary District, as it was known then, undertook a monumental task when it built a 28-mile-long channel that would connect the Chicago River with the Des Plaines River to reverse the flow of the river away from Lake Michigan.

The collection, storage, treatment, transmission and distribution of water played a significant role in urbanization, population growth and commercial agriculture and land use. Clean, potable water piped from afar led to the development of such large cities as Las Vegas, and the suburban areas around Chicago and Los Angeles. During the 20th century, water supply and distribution systems have led to an increase in life expectancy, reduction in infant mortality and morbidity, and improvements in environmental quality in developed countries.

The California State Water Project was selected as much for its remarkable engineering aspects, as for the positive impact it has had on regional economic trade and development. Conceived more than 50 years ago, a system of aqueducts, dams, reservoirs and plants meets the water resources needs of two-thirds of California's population.
Water Supply and Distribution

California Water Project

Features of the project include 32 storage facilities, reservoirs and lakes, 17 pumping plants, three pumping-generating plants, five hydroelectric power plants, and 660 miles of open canals and pipelines.

Water Transportation

The impact of canals and ports on economic and commercial development around the world is unsurpassed.

Passageways between bodies of water connect continents and create efficient interstate portals for cargo ships.

Canals and ports harness the capacity of water to carry extra large, bulky cargo, spurring economic growth, agricultural development, commerce and trade in all nations.

As cargo ships increase in size, engineers are developing new ways to expand ports, including dredging.

Water Transportation

The Panama Canal

The dream of Spanish conquistadors, the Panama Canal is one of civil engineering's greatest triumphs. Forty two thousand workers dredged, blasted and excavated the canal.

They moved enough earth and rubble between Colon and Balboa to bury Manhattan to a depth of 12-feet.

Water Transportation

The Panama Canal

The Third Set of Locks Project is a mega-project that will expand the Panama Canal.

The expansion will be greater than at any time since the canal's construction.

Panamanian President Martín Torrijos presented the plan on April 24, 2006 and Panamanian citizens approved it in a national referendum by 76.8% of votes on October 22, 2006.

The project will double the canal's capacity and allow more traffic.
The Panama Canal's expansion opened for commercial traffic on June 2016.

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Any Questions?