PHOENICIA UNIVERSITY

Introduction to Civil Engineering

Designing, Building, and Maintaining the World Around Us

Concepts, practices, case studies, and applied exercises

1 What Is Civil Engineering?

Civil engineering is the profession of planning, designing, constructing, and maintaining the built environment — roads, bridges, buildings, water systems, and infrastructure — that societies depend on safely every day.

It's not just roads and bridges.

- It spans structures, water systems, transportation networks, and environmental systems — visible buildings are only part of the picture.

It works at every scale.

- Civil engineers work on projects from a single house foundation to citywide transit systems and national infrastructure networks.

It's about service, not just structures.

- The goal is delivering infrastructure that is safe, functional, and cost-effective while serving communities for generations.

4,000+ Years

how far back the earliest civil engineering works — irrigation canals, roads, and monumental structures — can be traced, making it one of humanity's oldest professions

Well-designed infrastructure compounds over decades — a single sound bridge or water system quietly serves a community for generations.

2 The Three Pillars of Civil Engineering Design

Every civil engineering project must satisfy three interdependent pillars — a design succeeds only when all three are addressed together, not traded off against one another.

Safety

Ensuring structures and systems can safely withstand the loads, forces, and conditions they will face throughout their service life.

Serviceability

Designing structures that reliably perform their intended purpose — from everyday usability and comfort to long-term maintainability.

Economy

Delivering projects within budget and using materials and labor efficiently, so solutions remain affordable to build and maintain.

A design only qualifies as sound engineering when all three pillars are satisfied at once.

3 How Civil Engineering Evolved

2560 BCE

The Great Pyramid of Giza is completed, showcasing early large-scale structural design and construction management.

312 BCE

Roman engineers complete the Appian Way and major aqueducts, setting early standards for road and water-supply infrastructure.

1779

The Iron Bridge opens in England as the first major bridge built from cast iron, launching the use of modern structural materials.

1818

The Institution of Civil Engineers is founded in London, formally establishing civil engineering as a licensed profession.

1931

The Empire State Building is completed in about a year, showcasing modern skyscraper structural and construction techniques.

1994

The Channel Tunnel opens, linking England and France through one of the largest underwater tunneling projects ever completed.

From ancient monuments to global infrastructure networks, civil engineering has continually evolved to meet the needs of growing and changing societies.

4 Why It Matters Now

Civil engineering is no longer just about individual projects — it responds to pressures that affect infrastructure needs everywhere.

$94T

in global infrastructure investment needed by 2040 to keep pace with economic growth and demand

$15T

projected global infrastructure financing gap by 2040 if current investment trends continue

68%

share of the world's population projected to live in urban areas by 2050, up from 55% today

9.7B

projected global population by 2050, intensifying demand on housing, transport, water, and energy systems

This growth is driven by two forces at once: a growing, more urban population and aging infrastructure that must be rebuilt or expanded.

5 Core Sub-Disciplines of Civil Engineering

Structural Engineering

Designing buildings, bridges, and towers to safely carry loads and resist forces such as wind, gravity, and earthquakes.

Geotechnical Engineering

Studying soil and rock behavior to design safe foundations, tunnels, and retaining structures.

Transportation Engineering

Planning and designing roads, railways, airports, and traffic systems that move people and goods efficiently.

Water Resources Engineering

Managing water supply, drainage, flood control, and irrigation systems for communities and agriculture.

Construction Engineering & Management

Planning schedules, budgets, and methods to deliver projects safely, on time, and within budget.

Environmental Engineering

Designing systems for clean water, wastewater treatment, and pollution control to protect public health.

6 Example: The Burj Khalifa

The single-structure model: one building shows how structural, geotechnical, and mechanical engineering combine to push the limits of what can be built.

- Standing 828 meters tall with 163 floors, it used a reinforced-concrete buttressed core and a tapering Y-shaped floor plan to resist wind and gravity loads efficiently.
- Its foundation rests on a thick reinforced-concrete raft supported by hundreds of bored piles driven deep into the desert ground to carry the tower's immense weight.
- Its design relied on extensive wind-tunnel testing and computer modeling to keep the tower stable and comfortable at record-breaking heights.

828 m

the height of the Burj Khalifa, currently the tallest building in the world

190+

reinforced-concrete piles driven up to 50 meters deep to support the tower on soft desert soil

2010

year the Burj Khalifa officially opened, redefining what modern high-rise construction can achieve

Model takeaway: even the most ambitious single structure succeeds only when structural, geotechnical, and mechanical engineering are integrated from day one.

7 Example: The Netherlands' Delta Works

The infrastructure-scale model: safety is engineered directly into a nation's dams and barriers, not left to individual buildings alone.

- Built after the catastrophic North Sea flood of 1953, which killed more than 1,800 people, the Delta Works closes off river estuaries with a system of dams, sluices, and storm surge barriers.
- The Oosterscheldekering storm surge barrier stretches roughly 9 kilometers and is engineered to withstand a storm surge expected only once every 4,000 years.
- By damming estuaries and shortening the coastline that needed protection, the project reduced the length of dikes requiring ongoing maintenance by roughly 700 kilometers.

Model takeaway: large-scale infrastructure lets an entire nation manage risk collectively, rather than relying on every household to protect itself.

9 km

length of the Oosterscheldekering, one of the largest storm surge barriers in the Delta Works system

700 km

reduction in the length of dikes needing maintenance thanks to the project's design

1986

year the Delta Works were substantially completed, later named one of ASCE's Seven Wonders of the Modern World

8 Civil Engineering in Lebanon

Economic and infrastructure pressures have made civil engineering's role in Lebanon more visible and urgent than ever.

Beirut Port Explosion Recovery

The 2020 port explosion damaged thousands of nearby buildings, driving large-scale structural assessment, demolition, and rebuilding efforts led by local engineers.

Aging Roads & Water Networks

Decades of underinvestment have left many roads, bridges, and water systems in need of urgent rehabilitation to modern engineering standards.

Seismic Risk & Building Codes

Lebanon sits near active fault lines, making earthquake-resistant design and stronger enforcement of building codes a growing priority.

Decentralized Water & Solar Infrastructure

Chronic utility shortages have pushed engineers and communities toward decentralized water storage and renewable-powered civil works.

9 Sound Engineering vs. Cutting Corners

Not every finished structure reflects rigorous engineering — some create the appearance of safety without the underlying substance.

Signs of genuinely sound engineering:

- It is designed and reviewed by licensed engineers following recognized codes and standards, not just built to look finished.
- It is inspected and tested throughout construction, not only signed off once at the end.
- It accounts for its most demanding loading condition — earthquakes, floods, or heavy traffic — not just everyday use.

50+ Years

typical design service life engineers target for major structures such as bridges and buildings

1.5–2x

typical safety factor built into structural designs, so a structure can safely exceed its everyday expected loads

Genuine sound engineering is proven through code compliance, inspection, and testing — it isn't defined by how finished a structure looks on the outside.

10 Barriers in Civil Engineering Practice

Funding & Budget Constraints

Public infrastructure projects often compete for limited budgets, forcing trade-offs between scope, quality, and timeline.

Aging Infrastructure

Many roads, bridges, and water systems were built decades ago and require costly rehabilitation to meet current safety demands.

Regulatory & Permitting Delays

Zoning laws, permits, and environmental reviews can significantly slow down project approval and start dates.

Site & Soil Conditions

Unpredictable subsurface conditions — soft soil, high water tables, or seismic activity — can complicate foundation design.

Skilled Labor Shortages

A shortage of trained engineers, inspectors, and construction workers can affect project quality and schedules.

Climate & Environmental Pressures

Rising sea levels, extreme weather, and stricter environmental standards are reshaping design requirements for new projects.

11 Clarifications: Common Misconceptions

Misconception	Reality
“Civil engineers just design buildings.”	Civil engineering also covers roads, bridges, water systems, dams, airports, and environmental infrastructure — buildings are only one branch.
“Bigger or more expensive structures are automatically safer.”	Safety comes from sound design, quality materials, and proper construction — not size or cost alone.
“Once a structure is built, an engineer's job is done.”	Structures require ongoing inspection, maintenance, and monitoring throughout their service life.
“Civil engineering is just math and has little to do with people.”	Civil engineers must also weigh community needs, safety, budgets, and environmental impact in every design.

12 Class Exercise

Exercise 1: Structural Walk-Through

- Choose a building, bridge, or road you use regularly.
- Identify its likely structural system (columns, beams, trusses, or foundations).
- Note one design choice that likely balances safety, function, and cost.

Exercise 2: Infrastructure Case Check

- Bring in a news article or image of a civil engineering project — completed, under construction, or failed.
- Evaluate it against the “signs of sound engineering” from Slide 10.
- Is there evidence of proper design, inspection, or maintenance? What would make it more convincing?

Discuss: Which barrier from Slide 11 would most affect your Exercise 1 structure, and how might an engineer address it?

Key Takeaways

- Civil engineering is the profession of planning, designing, constructing, and maintaining the infrastructure — buildings, transportation, water systems — that societies rely on every day.
- Every design must satisfy three pillars — safety, serviceability, and economy — together, not traded off against one another.
- Civil engineering works at every scale — from a single skyscraper like the Burj Khalifa to nationwide systems like the Netherlands' Delta Works.
- Genuine engineering quality comes from rigorous design, inspection, and testing — not from how finished or impressive a structure looks.