# Civil engineering

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**A branch of engineering that encompasses the conception, design, construction, and management of residential and commercial buildings and structures, water supply facilities, transportation systems for goods and people, as well as control of the environment for the maintenance and improvement of the quality of life.** Civil engineering is a people-serving profession; it includes planning and design professionals in both the public and private sectors, contractors, builders, educators, and researchers who strive to meet the needs and desires of the community.

The civil engineer holds the safety, health, and welfare of the public paramount. Civil engineering projects and systems should conform to governmental regulations and statutes; should be built economically to function properly for a reasonable period of time with a minimum of maintenance and repair while withstanding anticipated usage and weather; and should conserve energy and allow hazard-free construction while providing healthful, safe, and environmentally sound utilization by society.

Because the desired objectives are so broad and encompass an orderly progression of interrelated components and information to arrive at the visually pleasing, environmentally satisfactory, and energy-frugal end point, civil engineering projects are actually systems requiring the skills and inputs of many diverse technical specialties, all of which are subsets of the overall civil engineering profession.

The infrastructure is the foundation of the modern industrialized urban society. The infrastructure includes roads; mass transit; railroads; bridges; airports; storage buildings; terminals; communication and control towers; water supply and treatment systems; storm water control systems; wastewater collection, treatment and disposal systems; as well as living and working areas, recreational buildings, and ancillary structures for civil and civic needs. Without a well-maintained and functioning infrastructure, the urban area, and society, cannot stay healthy, grow, and prosper. Civil engineers, with their

various technical specialties, play a major role in developing workable solutions to construct, renovate, repair, maintain, and upgrade this infrastructure. The civil engineer works with other professionals in developing functional projects, arriving at realistic cost estimates, and advocating reasonable investment strategies.

Civil engineers who move into management combine their technical training and skills with the ability to organize and properly employ the four basics of any project—personnel, time, materials, and money. Civil engineers in management may work for private engineering firms, for industries, for the military, for governmental agencies, or for regional authorities. The civil engineer may also choose a career in education. The teaching civil engineer educates students in technical specialties, inculcates engineering ethics and standards of safety, and engages in research and scholarly endeavors. Civil engineering faculty members are frequently involved as consultants or specialists on boards or commissions for standards, planning, or educational certification.

## *Photogrammetry, surveying, and mapping*

The civil engineer in this specialty precisely measures the Earth's surface to obtain reliable information for locating, planning, and designing engineering projects. This specialty involves everything from traditional land surveying to high-technology methods using aerial surveying, satellites, and computer-processing of photographic imagery. The information obtained by optical sighting, radio signal, laser scan, or sonic beam is converted to maps to provide accurate locations for designing planned developments, boring tunnels, building highways or pipelines, plotting flood control, irrigation or hydroelectric projects with dams and other structures, delimiting subsurface geologic formations that may affect construction projects, and aiding many other building uses. *See also:* **Aerial photography (/content/aerial-photography/012400)**; **Photometry (/content/photometry/510900)**; **Remote sensing (/content/remote-sensing/580900)**; **Surveying (/content/surveying/671800)**; **Topographic surveying and mapping (/content/topographic-surveying-and-mapping/700910)**

## *Community and urban planning*

Those engaged in this segment of civil engineering evaluate environmental, social, and economic factors in affecting the use and development of land and natural resources as they plan to establish planned developments, recreational park areas, or industrial complexes for regions, cities, or portions of a community. They work with other professionals to coordinate required infrastructure to ensure social, economic, and environmental well-being. *See also:* **Land-use planning (/content/land-use-planning/369800)**

## *Geotechnical engineering*

Civil engineers in this specialty analyze and evaluate the behavior of earth materials and the ability of these materials to support structures on or below the ground. They design and establish procedures to prevent the pressure or weight of structures from compressing the supporting earth and causing settlement. They are also concerned with methods to stabilize slopes and fills, to protect structures and infrastructure from earthquakes, and to mitigate the unwanted effects of ground water. *See also:* **Engineering geology (/content/engineering-geology/234000)**; **Foundations (/content/foundations/270400)**; **Permafrost (/content/permafrost/500000)**; **Pile foundation (/content/pile-foundation/516900)**; **Rock mechanics (/content/rock-mechanics/592200)**; **Soil mechanics (/content/soil-mechanics/631900)**

## *Construction engineering*

Civil engineers in this area manage and direct the physical construction of a project from start to finish; this field is also known as construction management. Construction engineers apply the knowledge of construction methods and equipment along with principles of financing, scheduling, planning, organization, and coordination to convert the paper designs into completed usable facilities. They maintain a continuous record of the personnel, time, materials, and costs expended and prepare periodic reports depicting the project's progress to completion. *See also:* **Construction engineering (/content/construction-engineering/158300)**; **Construction methods (/content/construction-methods/158500)**; **Engineering and architectural contracts (/content/engineering-and-architectural-contracts/233700)**

## *Structural engineering*

In this specialty, civil engineers plan, design, and evaluate a wide variety of structures, including buildings, bridges, offshore platforms, space platforms, amusement park rides, towers, and any other construction that must support its own weight and the loads it must carry. These structures must be designed for, and capable of withstanding, the loads due to rain, snow, or ice; the forces due to wind, hurricanes, and earthquakes; the effects of temperature changes and the like. The structural engineer must determine which construction materials or combinations of them such as steel, concrete, stone, brick, aluminum, plastics, and glass are most economical, safe, and appropriate for the project under the site-specific conditions. *See also:* **Bridge (/content/bridge/095500)**; **Buildings (/content/buildings/099000)**; **Structural analysis (/content/structural-analysis/662000)**; **Structural design (/content/structural-design/662250)**; **Structural materials (/content/structural-materials/662400)**; **Structure (engineering) (/content/structure-engineering/662800)**

## *Environmental engineering*

In this branch of the profession, civil engineers plan, design, construct, operate, and supervise systems to protect human health and the ecological balances necessary for environmental quality in both natural and humanmade environments. These systems include development and treatment of drinking water; collection and treatment of sanitary and industrial wastes to prevent contamination of the land and water; containment of hazardous and toxic materials; safe disposal of garbage, refuse, and other solid wastes; minimization or elimination of air pollution caused by industrial manufacturing or combustion processes; and design for containment of radioactive discharges. The environmental engineer is involved, either personally or through a team effort, to reduce, mitigate, or eliminate the hazards and risks associated with air, food, and water contaminants, radiation, toxic chemicals, solid wastes, disease vectors, safety hazards, and habitat alterations to preserve or conserve ecological biomes. *See also:* **Air pollution (/content/air-pollution/017700)**; **Hazardous waste (/content/hazardous-waste/309250)**; **Industrial wastewater treatment (/content/industrial-wastewater-treatment/757309)**; **Land reclamation (/content/land-reclamation/369650)**; **Sewage treatment (/content/sewage-treatment/617200)**; **Water pollution (/content/water-pollution/738900)**

## *Water resources engineering*

Civil engineers who specialize in this area deal with all aspects of the physical control of water. They plan, evaluate, design, construct, supervise, and operate systems to control floods; to supply water for cities; to develop irrigation; to manage and control river navigation, locks, and banks; to prevent beach erosion; and to maintain waterfront facilities. They are also involved in the planning and design of harbors, docks, wharfs, port facilities, canals, and offshore platforms and systems. They are involved with other civil engineers in planning and designing flood control dikes, dams, and hydroelectric power impoundments. *See also:* **Canal (/content/canal/105600)**; **Coastal engineering (/content/coastal-engineering/143800)**; **Dam (/content/dam/180300)**; **Harbors and ports (/content/harbors-and-ports/308000)**; **Reservoir (/content/reservoir/582100)**; **Revetment (/content/revetment/585100)**; **River engineering (/content/river-engineering/591100)**; **Water supply engineering (/content/water-supply-engineering/739200)**

## *Waste management and risk assessment*

Civil engineers involved in this area must function as a part of a team. The improper disposal of hazardous or toxic wastes, as well as the indiscriminate dumping of wastes in landfills, has created a situation that impacts on the land and subsurface water supplies. A subset of environmental engineering has evolved that is specifically concerned with the management of these sites. At the same time it is imperative that the available time, money, and personnel be utilized to treat these existing sites in a systematic and cost-effective manner. One method of establishing the hierarchy for treating the existing sites is to perform a risk assessment and establish which areas pose the greatest threat to people and natural resources. The civil engineers in this area of work must develop treatability procedures and estimate costs needed to reduce the risk. The data must then be presented to the public to explain the trade-offs of potential risk and the costs necessary to reduce them, since the locally affected community must be willing to expend time, effort, and money to clean up and manage the site. *See also:* **Risk assessment and management (/content/risk-assessment-and-management/590850)**

## *Transportation engineering*

Civil engineers working in this specialty plan, design, construct, and maintain facilities to safely and efficiently move people and goods. Accomplishing this task involves modal system planning for pedestrians, bikeways, streets, roads, highways, mass transit, railroads, airports, ports, and harbors. The ancillary structures to the vehicles and the travel way, which includes parking areas and terminals as the transfer facilities between the various modes of traffic, must be considered. Transportation engineers must apply technological acumen and consider the economic, social, and political factors that impact on each system. It is essential that transportation planning be done in conjunction with community and urban planners. The goal is an acceptable means of enhancing the movement of goods and people from residence to place of employment or entertainment, to shopping areas, and to health care facilities while always permitting quick response of emergency vehicles. The prosperity and quality of life of a community are intimately tied up with the transportation system. *See also:* **Airport engineering (/content/airport-engineering/020100)**; **Highway engineering (/content/highway-engineering/318700)**; **Railway engineering (/content/railway-engineering/572000)**; **Transportation engineering (/content/transportation-engineering/706700)**

## *Pipeline engineering*

Civil engineers in this highly specialized task of transporting liquids, gases, or slurries plan, design, maintain, and operate the pipelines in which these various types of noncombustible to highly combustible materials are moved from one location to another. The engineers determine pipeline design, location, and the environmental and economic impacts on the region that the line traverses. They select the material for constructing the line based on the qualities of durability and safety. Further, they specify installation techniques, methods of testing, and controls for maintaining proper pressure and rate of flow of the material within the line. When a hazardous or toxic material is to be carried, safety is a major concern. *See also:* **Engineering (/content/engineering/233600)**; **Pipeline (/content/pipeline/519100)**

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