ASSIGNMENT

MTST-602

FINITE ELEMENT METHOD

What is engineering?

Engineering is the application of scientific, economic, social, and practical knowledge in order to invent, design, build, maintain, research, and improve structures, machines, devices, systems, materials, and processes.

The term Engineering is derived from the Latin word ingenium, meaning "cleverness" and ingeniare, meaning "to contrive, devise".

The discipline of engineering is extremely broad, and encompasses a range of more specialized fields of engineering, each with a more specific emphasis on particular areas of applied science, technology and types of application.

History

Engineering has existed since ancient times as humans devised fundamental inventions such as the wedge, lever, wheel, and pulley. Each of these inventions is essentially consistent with the modern definition of engineering.

The word "engine" itself is of even older origin, ultimately deriving from the Latin ingenium and meaning "innate quality, especially mental power, hence a clever invention.

The term engineering itself has a much more recent etymology, deriving from the word engineer, which itself dates back to 1325, when an engineer (literally, one who operates an engine) originally referred to “a constructor of military engines. “In this context, now obsolete, an “engine” referred to a military machine, i. e. a mechanical contraption used in war. The word “engine” itself is of even older origin, ultimately deriving from the Latin ingenium, and meaning “innate quality, especially mental power, hence a clever invention.” Later, as the design of civilian structures such as bridges and buildings matured as a technical discipline, the term civil engineering entered the lexicon as a way to distinguish between those specializing in the construction of such non-military projects and those involved in the older discipline of military engineering (the original meaning of the word “engineering,” now largely obsolete, with notable exceptions that have survived to the present day such as military engineering corps.

Ancient

The Pharos of Alexandria, the pyramids in Egypt, the Hanging Gardens of Babylon, the Acropolis and the Parthenon in Greece, the Roman aqueducts, Via Apia and the Colosseum, Teotihuacán and the cities and pyramids of the Mayan, Inca and Aztec Empires, the Great Wall of China, the Brihadeeswarar Temple of Thanjavur and tombs of India, among many others, stand as a testament to the ingenuity and skill of the ancient civil and military engineers.

Ancient Greece developed machines in both civilian and military domains. The Antikythera mechanism, the first known mechanical computer, and the mechanical inventions of Archimedes are examples of early mechanical engineering. Some of Archimedes' inventions as well as the Antikythera mechanism required sophisticated knowledge of differential gearing or epicycle gearing, two key principles in machine theory that helped design the gear trains of the Industrial Revolution, and are still widely used today in diverse fields such as robotics and automotive engineering. Chinese, Greek and Roman armies employed complex military machines and inventions such as artillery.

The steam engine major driver in industrial revolution

The pyramids

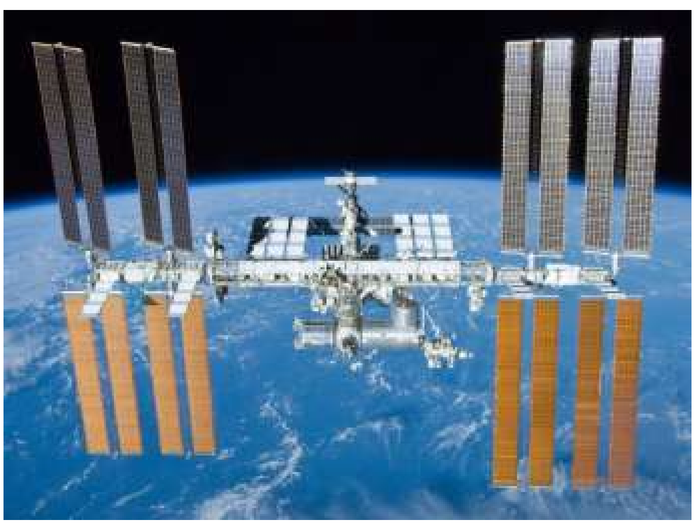
Later, as the design of civilian structures such as bridges and buildings matured as a technical discipline, the term civil engineering entered the lexicon as a way to distinguish between those specializing in the construction of such non-military projects and those involved in the older discipline of military engineering.

Modern era

The early stages of electrical engineering included the experiments of Alessandro Volta in the 1800s, the experiments of Michael Faraday, Georg Ohm and others and the invention of the electric motor in 1872. The work of James Maxwell and Heinrich Hertz in the late 19th century gave rise to the field of electronics. The later inventions of the vacuum tube and the transistor further accelerated the development of electronics to such an extent that electrical and electronics engineers currently outnumber their colleagues of any other engineering specialty.

The inventions of Thomas Savery and the Scottish engineer James Watt gave rise to modern mechanical engineering. The development of specialized machines and their maintenance tools during the industrial revolution led to the rapid growth of mechanical engineering both in its birthplace Britain and abroad. Structural engineers investigating NASA's Mars-bound spacecraft, the Phoenix Mars Lander

John Smeaton was the first self-proclaimed civil engineer, and is often regarded as the "father" of civil engineering. He was an English civil engineer responsible for the design of bridges, canals, harbors and lighthouses. He was also a capable mechanical engineer and an eminent physicist. Smeaton designed the third Eddystone Lighthouse (1755–59) where he pioneered the use of 'hydraulic lime' (a form of mortar which will set under water) and developed a technique involving dovetailed blocks of granite in the building of the lighthouse. His lighthouse remained in use until 1877 and was dismantled and partially rebuilt at Plymouth Hoe where it is known as Smeaton's Tower. He is important in the history, rediscovery of, and development of modern cement, because he identified the compositional requirements needed to obtain "hydraulicity" in lime; work which led ultimately to the invention of Portland cement.



The International space station represents modern Engineering

The Falkirk Wheel in Scotland

What is civil engineering?

Civil engineering is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including works like roads, bridges, canals, dams, and buildings.

Civil engineering is the second-oldest engineering discipline after military engineering, and it is defined to distinguish non-military engineering from military engineering. It is traditionally broken into several sub-disciplines including architectural engineering, environmental engineering, geotechnical engineering, control engineering, structural engineering, earthquake engineering, transportation engineering, forensic engineering, municipal or urban engineering, water resources engineering, materials engineering, wastewater engineering, offshore engineering, facade engineering, quantity surveying, coastal engineering, construction surveying, and construction engineering. Civil engineering takes place in the public sector from municipal through to national governments, and in the private sector from individual homeowners through to international companies.

History

Civil engineering is the application of physical and scientific principles for solving the problems of society, and its history is intricately linked to advances in understanding of physics and mathematics throughout history. Because civil engineering is a wide ranging profession, including several separate specialized sub-disciplines, its history is linked to knowledge of structures, materials science, geography, geology, soils, hydrology, environment, mechanics and other fields.

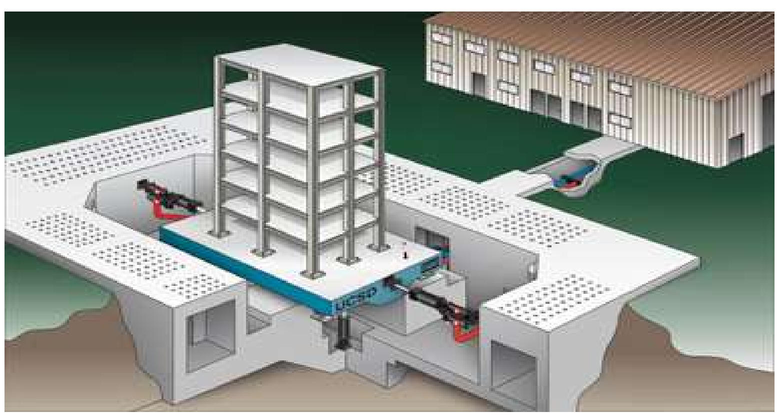
Throughout ancient and medieval history most architectural design and construction was carried out by artisans, such as stonemasons and carpenters, rising to the role of master builder. Knowledge was retained in guilds and seldom supplanted by advances. Structures, roads and infrastructure that existed were repetitive, and increases in scale were incremental. One of the earliest examples of a scientific approach to physical and mathematical problems applicable to civil engineering is the work of Archimedes in the 3rd century BC, including Archimedes Principle, which underpins our understanding of buoyancy, and practical solutions such as Archimedes' screw.

Aqueduct built by roman in 19 BC

Sub-disciplines

In general, civil engineering is concerned with the overall interface of human created fixed projects with the greater world. General civil engineers work closely with surveyors and specialized civil engineers to design grading, drainage, pavement, water supply, sewer service, dams, electric and communications supply. General civil engineering is also referred to as site engineering, a branch of civil engineering that primarily focuses on converting a tract of land from one usage to another. Site engineers spend time visiting project sites, meeting with stakeholders, and preparing construction plans. Civil engineers apply the principles of geotechnical engineering, structural engineering, environmental engineering, transportation engineering and construction engineering to residential, commercial, industrial and public works projects of all sizes and levels of construction.

- Materials science and engineering
- Coastal engineering
- Construction engineering
- Earthquake engineering
- Environmental engineering
- Geotechnical engineering
- Water resources engineering
- Structural engineering
- Surveying
- Transportation engineering
- Forensic engineering
- Municipal or urban engineering



Large high performance shake table, Earthquake engineering

What is structural engineering?

Structural engineering is a field of engineering dealing with the analysis and design of structures that support or resist loads.

Structural engineers are most commonly involved in the design of buildings and large non building structures but they can also be involved in the design of machinery, medical equipment, vehicles or any item where structural integrity affects the item's function or safety. Structural engineers must ensure their designs satisfy given design criteria, predicated on safety (i.e. structures must not collapse without due warning) or serviceability and performance (i.e. building sway must not cause discomfort to the occupants).Structural engineering theory is based upon applied physical laws and empirical knowledge of the structural performance of different materials and geometries. Structural engineering design utilizes a number of simple structural elements to build complex structural systems. Structural engineers are responsible for making creative and efficient use of funds, structural elements and materials to achieve these goals.

Structural design is a systematic and iterative process that involves:

1) Identification of intended use and occupancy of a structure – by owner

2) Development of architectural plans and layout – by architect

3) Identification of structural framework – by engineer

4) Estimation of structural loads depending on use and occupancy

5) Analysis of the structure to determine member and connection design forces

6) Design of structural members and connections

7) Verification of design

8) Fabrication & Erection – by steel fabricator and contractor

Structural engineers are responsible for the detailed analysis and design of following structures

Architectural structures: Buildings, houses, factories. They must work in close cooperation with an architect who will ultimately be responsible for the design.

Civil Infrastructures: Bridges, dams, pipelines, shore structures. They work with transportation, hydraulic, nuclear and other engineers. For those structures they play the leading role.

Aerospace, Mechanical, Naval structures: aero planes, spacecraft's, cars, ships, submarines to ensure the structural safety of those important structures.

History of Structural Engineering

Structural engineering dates back to 2700 B.C.E. when the step pyramid for Pharaoh Djoser was built by Imhotep, the first engineer in history known by name. Pyramids were the most common major structures built by ancient civilizations because the structural form of a pyramid is inherently stable and can be almost infinitely scaled (as opposed to most other structural forms, which cannot be linearly increased in size in proportion to increased loads)

Throughout ancient and medieval history most architectural design and construction was carried out by artisans, such as stone masons and carpenters, rising to the role of master builder. No theory of structures existed, and understanding of how structures stood up was extremely limited, and based almost entirely on empirical evidence of 'what had worked before'. Knowledge was retained by guilds and seldom supplanted by advances. Structures were repetitive, and increases in scale were incremental. No record exists of the first calculations of the strength of structural members or the behavior of structural material, but the profession of structural engineer only really took shape with the Industrial Revolution and the re-invention of concrete. The physical sciences underlying structural engineering began to be understood in the Renaissance and have since developed into computer-based applications pioneered in the 1970s.

Civil engineering structures

Civil structural engineering includes all structural engineering related to the built environment. It includes:

- Bridges
- Dams
- Earthworks
- Foundations
- Offshore structures
- Pipelines
- Power stations
- Railways
- Retaining structures and walls
- Roads
- Tunnels
- Waterways
- Water and wastewater infrastructure

What is Design?

Structural design is the methodical investigation of the stability, strength and rigidity of structures. The basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure during its intended life. The primary purpose of a structure is to transmit or support loads. If the structure is improperly designed or fabricated, or if the actual applied loads exceed the design specifications, the device will probably fail to perform its intended function, with possible serious consequences. A well-engineered structure greatly minimizes the possibility of costly failures.

Designing often necessitates considering the aesthetic, functional, economic and sociopolitical dimensions of both the design object and design process. It may involve considerable research, thought, modeling, interactive adjustment, and re-design. Meanwhile, diverse kinds of objects may be designed, including clothing, graphical user interfaces, skyscrapers, corporate identities, business processes and even methods of designing.

Structural design process

A structural design project may be divided into three phases, i.e. planning, design and construction.

Planning: This phase involves consideration of the various requirements and factors affecting the general layout and dimensions of the structure and results in the choice of one or perhaps several alternative types of structure, which offer the best general solution. The primary consideration is the function of the structure. Secondary considerations such as aesthetics, sociology, law, economics and the environment may also be taken into account. In addition there are structural and constructional requirements and limitations, which may affect the type of structure to be designed.

Design: This phase involves a detailed consideration of the alternative solutions defined in the planning phase and results in the determination of the most suitable proportions, dimensions and details of the structural elements and connections for constructing each alternative structural arrangement being considered.

Construction: This phase involves mobilization of personnel; procurement of materials and equipment, including their transportation to the site, and actual on-site erection. During this phase, some redesign may be required if unforeseen difficulties occur, such as unavailability of specified materials or foundation problems.

Philosophy of designing

The structural design of any structure first involves establishing the loading and other design conditions, which must be supported by the structure and therefore must be considered in its design. This is followed by the analysis and computation of internal gross forces as well as stress intensities, strain, deflection and reactions produced by loads, changes in temperature, shrinkage, creep and other design conditions. Finally comes the proportioning and selection of materials for the members and connections to respond adequately to the effects produced by the design conditions.The criteria used to judge whether particular proportions will result in the desired behavior reflect accumulated knowledge based on field and model tests, and practical experience. Intuition and judgment are also important to this process.

The traditional basis of design called elastic design is based on allowable stress intensities which are chosen in accordance with the concept that stress or strain corresponds to the yield point of the material and should not be exceeded at the most highly stressed points of the structure, the selection of failure due to fatigue, buckling or brittle fracture or by consideration of the permissible deflection of the structure. The allowable – stress method has the important disadvantage in that it does not provide a uniform overload capacity for all parts and all types of structures.

What is analysis?

Analysis is the process of breaking a complex topic or substance into smaller parts in order to gain a better understanding of it. The technique has been applied in the study of mathematics and logic since before Aristotle (384–322 B.C.), though analysis as a formal concept is a relatively recent development. It has also been ascribed to Isaac Newton, in the form of a practical method of physical discovery.

Engineering analysis involves the application of scientific analytic principles and processes to reveal the properties and state of a system, device or mechanism under study. Engineering analysis is decompositional; it proceeds by separating the engineering design into the mechanisms of operation or failure, analyzing or estimating each component of the operation or failure mechanism in isolation, and re-combining the components according to basic physical principles and natural laws.

Given an existing structure subjected to a certain load determine internal forces (axial, shear, flexural, torsional; or stresses), deflections, and verify that no unstable failure can occur.

Thus the basic structural requirements are:

Strength: stresses should not exceed critical values

Stiffness: deflections should be controlled

Stability: buckling or cracking should also be prevented